THURSDAY, NOVEMBER 13, 1879

DEMONOLOGY AND DEVIL-LORE

Demonology and Devil-Lore. By Moncure Daniel Conway, M.A., B.D., of Divinity College, Harvard University, Cambridge, U.S.A. Member of the Anthropological Institute, London. With numerous Illustrations. 2 vols. 8vo. (London: Chatto and Windus, Piccadilly, 1879.)

THESE two volumes carry us back to the period when existing creeds were embryonic, and when primitive man was creating his religion from his environment. The lights of heaven, animal and vegetable life, the elements and natural phenomena supplied the raw material of mythology, and received embodiment as anthropomorphic deities. Mr. Conway premises the inexactness of speaking of the worship of stock and stone, of insect and reptile as primitive. He expresses his belief that these only acquired intrinsic sanctity when the origin of their imputed sacredness was lost—the progress of ideas being from the far to the near, and not from the near to the far. Macaulay has attributed a monotheistic faith to the first inhabitants of Greece. Chalmers has done as much for China, and Mr. Brown, in his great Dionisiak Myth, has stated his conviction that "there is no gradual evolution in human thought, and that the earliest stages of religion and worship were infinitely superior to those which succeeded them." But whilst he endorses these opinions, Mr. Conway must remember that they are not shared by other competent authorities. Dr. Goldziher, for instance, stoutly maintains that religion was painfully evolved from mythology, and that polytheism has been the invariable precursor of faith in a single God. In this conflict of opinion we are as unprepared to decide whether worship rose from the idol to the Deity, or sank from the pure religion of a golden age into the vagaries of a degraded mythology, as we are to determine whether an adoration of the generative powers preceded or grew out of that of the sun. In the present state of our knowledge we must be content to suspend our judgment; but in examining Mr. Conway's work we must remember that it rests upon a theory which at least is not proven.

The undefined pantheism of primitive awe, says Mr. Conway, gradually melted into dualism, and the varying aspects of the Almighty as distributor of good and evil caused his separation into distinct embodiments of these principles. This is doubtless, in a sense, perfectly true: "theism is found side by side with unconscious pantheism, of which it is only an expression," and the Jew had in Jehovah a distributor of the evil as well as of the good before he evolved, or inherited, the conception of Satan. We are, however, inclined to believe that the first supernatural power which forces a conviction of its existence upon the mind of the savage is that of evil, and that the idea of a beneficent being is both subsidiary and of later occurrence. First, the embodiment of evil is feared and propitiated; next, when invoked successfully for the destruction of the worshipper's enemies, he begins to exhibit (to his worshipper at least), an amiable phase of his character, and the conflicting elements which thus come into play form the germs of the rival entities of God and Devil.

The first volume of the work, which is in two sections, deals with the Demon and its development into the Dragon, whilst the second volume is devoted to the Devil. This latter volume is filled with the theological conceptions which originated and developed the personification of abstract evil. These are scarcely suited for discussion in our pages, and for an account of their subtle gradations we must refer our readers to the book itself. The demon, however, is not theological but natural; it is a being the harmfulness of which is not gratuitous, but incidental to the gratification of its desires. It is the embodied expression of the natural obstacles with which savage man found himself obliged to contend, and hunger, heat, cold, wild beasts, the warring elements, darkness, disease, and death were the causes to which it owed its birth. It was to propitiate the hungry demon that sacrifices were instituted: in the hope that such offerings might satisfy the insatiate appetite of the monster to which not only human hunger and privation, but also eclipses were held to be due. Here we may offer an explanation, omitted by Mr. Conway, which throws light upon the character of this devourer of the sun and moon. From the most remote antiquity the two points at which the ecliptic and the moon's orbit intersect each other were called the head and tail of the dragon. As these are the points at which eclipses happen we see at once why astronomers fabled the existence of a monster which devoured the sun and moon. Once started the progress of the myth was easy, and after many varying phases the hunger fiend found its later developments in the form of the ogre and the vampire. Mr. Conway says that the visible consumption of sacrifice by fire in part originated the belief that it was the element of fiends, but it appears—on his theory that the progress of thought was from the far to the near—more probable that the sun having been the primary object of worship lent its characteristic of heat to some of the abstractions to which it gave rise. This class of demon was modified as the painful action of intense heat, in the desert sand, in sunstroke, and in drought, was observed by man. The worship of the sun in heaven would pass easily into the worship of his natural representative of fire on earth. In opposition to light and heat we find darkness and cold personified, and trace in such tales as the descent of Ishtar to Hades and the deaths of Baldur and Adonis the grief of man for the loss of the sun.

A propos of cold Mr. Conway reminds us that hell, which we are accustomed to regard as unpleasantly warm, really means a place of fireless darkness—fire being far too agreeable in northern latitudes to be regarded with disfavour, and he traces the superstitious desire for burial to the south side of a church to a wish for proximity to the happy abodes of Brimir and Sindri—fire and cinders! This passage is instructive, apart from its humour, for it teaches us how in the constant revolution of opinion the god of to-day is the fiend of the morrow, and how, as Mr. Fiske has pointed out, the German Abgott sums up in a single etymology the history of the havoc wrought by the monotheistic idea amongst the ancient symbols of Deity. To this degradation certain later forms of demon were due, and it is thus that the gipsy language retains as the word for God that which we employ as the appellation of the devil.

Mr. Conway passes in review the myths which spring from lightning, as the blasting-eye of Siva, the dart of Rudra, the spear of Odin, and the sword of St. George; and treats of the typhoon caused by the passing of the bob-tailed dragon and the various embodiments of whirlwind and waterspout, of sand-cloud and flood. He next proceeds to deal with the animal demons; and here, whilst we find much amusing folk-lore, we are surprised that he has not worked out that degradation of deities to which he himself alludes, and which might here be so effectively produced. Thus, although we have a suggestion of association between the hare and the moon, due probably to the resemblance of their Sanskrit names, and a statement that the lion is a symbol of majesty and of the sun in his glory reached in the zodiacal Leo, we have no hint of the extremely important change from the worship of the bull to that of the lamb due to the precession of the equinox, which brought a different sign for adoration at the vernal equinox, and which caused, in all probability, the substitution of the Pascal Lamb for the worship of Apis; this feast of the *transit* having its remembrance at the present day in the hot *cross* bun. Similarly we have no explanation of the association of the ass, the cock, and the goat with phallic ritual, though their association with the most holy rites of that creed could not fail to have diabolised them in the eyes of adherents to succeeding faiths. The Pleiades, the Succoth Benoth of the Chaldeans, were represented by a hen gathering her chickens under her wings; and we are surprised that Mr. Conway, who rarely loses an opportunity for startling the orthodox, has not here found a parallel to Christ's lament over Jerusalem. He has an interesting notice of the wehr-wolf, which was seemingly suggested by Mr. Fiske's excellent little work, "Myths and Myth-Makers," a volume to which, if we mistake not, Mr. Conway is much indebted. The animal kingdom thus furnished its quota of demons, and we are shown how every force which could be exerted injuriously in claw, fang, sting, or hoof, was pressed into the service of evil.

Hostile races were demonised of old, just as is the kidnapping white man of to-day amongst the black races of Africa. The varying physique of contending nations may have originated the myths of giants and dwarfs. A small people possessed of superior intellectual powers would scarcely fail to impress their huger opponents; though we must not lose sight of the gigantic features which are so frequently associated with solar heroes, and which may, perhaps, suggest a more satisfactory explanation. With our recent experience of famine in India, we shall have no difficulty in understanding the dread in which its embodiment was held, nor the adoration of the Hindu for the rain-giving Indra. Yet Mr. Conway justly laments that this adoration has taken the form of temple building throughout the land, for the offering of a worship impotent to arrest the famine demon, whose course might have been stayed had the expenditure thus lavished been devoted to observatories—since modern science has pointed out the relation existing between sun-spots and years of scarcity. He at the same time reminds us that we are more intent upon scaring our own people with the hell and devils which we have inherited from our pagan forefathers, than in endeavouring to remedy the demoniacal vice, infamy, and misery by which we are surrounded. We cannot follow Mr. Conway through his long and interesting catalogue of the other natural features which have been demonised—the mountain steep, the gloomy night, the mysteries of disease and of death—this he has worked out with great care, and a *résumé* of these sections would fail to afford an idea of their interest. These natural obstacles personified and demonised by man having played their part, shrunk, as he advanced in civilisation, from their terrible proportions, to make way for more general forms expressing comparatively abstract conceptions of physical evil.

On the one hand stood moral man, on the other unmoral nature. Man had by this time discovered that moral order in nature was represented solely by his own power; the good gods were now respected only as incarnate in men, whilst the active powers of evil remained hateful and hurtful to man, each becoming more purely a demon, and passing on to become a devil. Man in his growing culture gave a more symbolic cast to those representations, which had hitherto been purely naturalistic, and those semi-metaphysical conceptions were evolved which Mr. Conway classes under the general heading of dragon. In this class come the chimæra and sphinx, huge worm and serpent, Behemoth and Leviathan. Finally, the terrible conclusion that evil is a positive and imperishable principle in the universe—the notion of remorseless fate—of arbitrary will to which every human agony is attributable, detached from universal organic necessity, gave birth to the stupendous conception of embodied abstract evil in the person of the devil.

Only those who have attempted an investigation similar to the present one of Mr. Conway can appreciate the patient labour incident to the collection of widely-scattered materials and the mass of varied reading necessary to fit the author for his task, and we are happy to bear witness to the evidences of careful preparation with which these volumes abound. It is to be regretted that his excellent matter is frequently enveloped in rhetorical embellishments which render the comprehension of his meaning difficult. Mr. Conway's style of writing is characterised by recapitulation, want of concentration, and a constant parenthetical introduction of matter only collaterally related to the subject in hand, which render parts of his book far from easy reading. His explanations of the formation of legendary characters and of myths appear to us at times somewhat strained, and he leans unduly upon the metaphysical aspect of the question to the exclusion of those archæological and astronomical explanations which would have so greatly enhanced the value of his work. He has indeed dealt with phases of folk-lore, and has shown how physical and material wants were crystallised as entities, but he has, in our opinion, failed to make out, as he might have done, the genealogy of the infernal powers, and to cite those explanations which a knowledge of the astronomy of the ancients so constantly affords. In illustration of our remark, we may instance his treatment of one of the most important myths, that of Bel and the Dragon. He mentions that Bel is lord of the surface of the earth, including the atmosphere, and quotes long translations from tablets, giving accounts of the conflict as it w known to the Babylonians. He compares Bel's sword

with that mentioned in Genesis as turning every way to guard the tree of life; he tells us that the Bel whom Milton saw was Cromwell and the dragon the serpent of English oppression; and that to the Jews the power of Christendom came to be represented as the reign of Bel. But out of all this he obtains nothing further than an identification of Bel with Michael in the Apocalypse. This is sufficiently provoking when we remember the astronomical and cosmical facts which underlie the story. Were we possessed of no further evidence than that afforded by the great pyramid, we should be at no loss to perceive the anxious care with which the heavenly bodies were observed by the ancients. A star-group which specially claimed their attention was the Pleiades. The Pleiades above the horizon were the celestial, and below it the infernal gods. The period of their culmination, typifying appropriately a deliverance from Hades of the departed, has been dedicated, throughout the Old and New Worlds, to the worship of the manes of ancestors. This festival survives in our All Saints Day the accompanying feasts of Hallow-e'en and All Souls, originating in the imperfection of ancient observations. Wanting instruments of sufficient accuracy to determine the exact time of culmination, the ancients, by extending their devotions over three days, secured a due celebration of the sacred epoch. One act of this solemn period was lighting the sacred fire. The *Times* of November 4 records that Her Majesty was graciously pleased to assist at that holy rite, and witnessed the burning in effigy of a witch, personification of the evil power. This fire, the Bealltainn or Beltin, was the fire of Bel, and celebrated his ascension to the zenith, whilst his adversary, the dragon, was cast down to the nadir. In the rising of the Pleiades, at the time that Scorpio sank below the horizon, we may see the victory of Bel over the Dragon—a victory always negatived, as autumn gave place to winter, and ever renewed as winter was succeeded by spring, the alternating success of the combatants being fitly recorded in a joint worship. When we remember the identification of the Cherubim with the Bull, and of the Seraph with Scorpio, we perceive that their continual cry is but another expression of the eternal struggle. Again, in a mystic sense, we must remember that in Babylonian mythology Bel was Saturn, the oldest and chief god, the great spirit of antiquity, the ancient of days, God of Heaven, Life God, Lord of the Cycles, Chronos, Eternal God. His emanation was light, and in his character of sun god he was the creator—Demiurgus and Logos—and in this phase he combats and overcomes Tiamat or evil chaos, as the heavenly spirit in Genesis broods over the abyss of darkness—this idea is reproduced in another Babylonian legend, in which Bel cuts the woman Omorka, or primitive matter, in halves, and forms heaven and earth of the pieces. We can readily understand that on the promulgation of the doctrine that the gods were originally men whose virtue had raised them to the skies, the heroic deeds of Bel were related as those of a giant over natural foes, and that the first of the gods became the first man, equivalent to Adam. And so we find that, in company with his wife Beltis (Eve), he preceded the antediluvian rule of the ten zodiac gods. But Bel was, as the highest abstraction of deity, himself hermaphrodite, and in that sense active heaven and passive earth—light and darkness. He is thus the dragon-slayer and the great serpent itself, a fact which will account for the two personifications being the objects of a joint worship equivalent to the linga-yoni worship of India.

To the getting up of the work we have nothing to object except as regards the illustrations, which, though fair, scarcely reach that standard which the excellence of the text deserves. Debited, however, with any faults which it may contain, a large balance remains to the credit of its learned author, and if he has not succeeded in producing an exhaustive treatise upon his subject, his volumes are undoubtedly a most valuable contribution to Demonology, and we trust they may meet with the success to which they are unquestionably entitled.

OUR BOOK SHELF

Fauna der Gaskohle und der Kalksteine der Permformation Böhmens. Von Dr. Ant. Fritsch, Band i. Heft i. (Prague, 1879.)

THE accomplished professor of zoology, in the university of Prague, publishes in this part, which consists of ninety-two folio pages and twelve beautiful plates, descriptions of the sections of the rocks whence the fossils were derived, lists of the fossils, and a careful *résumé* of the literature of the extinct amphibia, which are usually jumbled up together under the term Labyrinthodontia. The most valuable part of the work is an elaborate description of the new forms which abound in the strata overlying the Silurians, in a region where the Pilsner district may be considered typical. The Gaskohle there yielded a very rich fauna and flora of twenty-one new labyrinthodont species, some Orthacanthoids and species of Xenacanthus, Acanthodes, and Palæoniscus; besides Estheria, portions of Orthoptera and Julus. The plants named by O. Feistmantel were numerous and the few typical Permian forms are:—*Equisetites contractus*, *Neuropteris imbricata*, *Odontopteris obtusiloba*, and *Schlotheimi*, *Asterocarpus Geinitzii*, *Schützia anomala*, and *Walchia piniformis*. With these are Sigillaria, Stigmaria, Volkmannia, Calamites, Lepidodendra, &c. The new amphiban genus Branchiosaurus is represented by five species in the whole district, Sparodus by two, Hylonomus by the same number, and there is a form called Dawsonia. In noticing the family Branchiosauridæ Dr. Fritsch draws attention to the necessity of allowing the name Stegocephali to replace that of the Labyrinthodontia for the order, as the labyrinthic condition of the teeth is not seen in skulls in which the supra-occipitals are two distinct ossifications, where there are post-orbital and supra-temporal bones, as well as well-developed epiotics, a sclerotic ring being present. The family just alluded to are broad-headed salamander-looking things with smooth teeth with large cavities. They have short ribs, vertebræ with relics of the chorda, and the parasphenoid is in the shape of a broad plate, which narrows in front. The skin is covered with delicate ornamented scales, and the remains of branchial rays are present. One of these, *Branchiosaurus salamandroides*, already described by the author, is carefully illustrated, and is a form well worth studying. Its osteology is plainly given, and the remnants of the breast plate and of the shoulder girdle and pelvis also. The new genus Sparodus has remarkably broad bones, which may be vomers, which carry numerous conical teeth, and the fore part of the parasphenoid is short and broad, and the palatines have a row of teeth on them. Allied to *Hylerpeton*, Owen, and *Batrachiderpeton*, Hancock, Sparodus has about seventeen teeth in the lower jaw

on either side and the front ones are double the size of the others. The genus Dawsonia, allied more or less to *Hylonomus*, Dawson, is also one of those broad frog-headed salamandroid-looking branchiate amphibia. The sculpturing of the head plates is remarkable, and there appears to be a new bone interpolated behind the post-frontal. Beneath, the vomers have teeth, and so have the long part of the pre-sphenoid, the outer portions of the pterygoids, the palatines, superior-maxillaries, and the pre-maxillaries. The clearly written book is made all the more valuable by the introduction of Miall's reports to the British Association on the labyrinthodonts, and it is pleasing to note the author's graceful recognition of the assistance, he has had in his work from British palæontologists.

P. M. D.

LETTERS TO THE EDITOR

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts. No notice is taken of anonymous communications.*

[*The Editor urgently requests correspondents to keep their letters as short as possible. The pressure on his space is so great that it is impossible otherwise to ensure the appearance even of communications containing interesting and novel facts.*]

An Account of some Marine Animals met with *en route* to the Cape September 21, 22

I AM commanded by my Lords Commissioners of the Admiralty, to transmit herewith a copy of a letter from the commanding officer of H.M.S. *Crocodile*, giving an account of some marine animals met with *en route* to the Cape, which may be of some interest to the readers of NATURE.

Admiralty, November 10 ROBERT HALL

H.M.S. *Crocodile*, Simon's Bay
September 30, 1879

SIR,—I think the following statement may be of some scientific interest, and have the honour to request that it may be attached to my letter of proceedings of this day's date.

Between the Lat. of $\left\{\begin{matrix}5°\ 53'\\9°\ 48'\end{matrix}\right\}$ S., and Long. $\left\{\begin{matrix}5°\ 44'\\7°\ 32'\end{matrix}\right\}$ E., and between the hours of moon setting and daylight on the nights of September 21 and 22, the condensers were continually heating, and the vacuum gauge suddenly dropping to zero.

On examination of strainers, it appeared that the inlet to the sea-water was choked with a marine animal to an extent that necessitated stopping and clearing four times on the night of the 21st inst., and five times on the night of the 22nd inst.

On referring to Dallas's "Natural History," the description given of the Pyrosoma, class Tunicata, order Ascidia, corresponded in all apparent particulars to the specimens I fished up from alongside and took from off the strainers. Those on the strainers were, of course, much flattened by the pressure, and those that had passed through were much attenuated.

The luminosity of the creatures was very great, and of a most brilliant sapphire colour. I have, &c.,

(Signed) F. PROBY DOUGHTY,
Captain

To Commodore Richards, A.D.C., Cape of Good Hope

Easter Island

As the reviewer of Australasia in NATURE, vol. xx. p. 598, I must ask space for a few further words with regard to Rapanui. Mr. Albert J. Mott draws conclusions with regard to the ancient navigation of the Pacific Ocean and a former condition of high civilisation of the erectors of the stone images, which will not be admitted by any scientific ethnologist. The difficulties attending the erection by savages, or very slightly civilised people all over the world, of large stones has been greatly overrated. In the case of the stone images of Easter Island, the latest observer, M. A. Pinart, who has paid great attention to this very question and published the fullest account of the matter, together with a series of excellent illustrations, finds no difficulty in accounting for their erection. He writes as follows:—"L'ensemble de ce vaste atelier de statues gigantesques les unes entièrement terminées les autres à l'état d'ébauche et en voie d'exécution nous permet de nous rendre compte de la façon dont le travail était accompli, et de la manière dont elles étaient érigées et mise en place après leur complet achèvement. L'exécution de ce travail qui de prime abord parait considérable, qui à tout étonné les voyageurs et *suggère de nombreuses hypothèses*, est cependant d'une grande simplicité."

M. Pinart then goes on to explain how the sculptures were always cut out on rocks considerably inclined, and slid down hill to the place assigned, where they were tilted by means of an inclined plane of earth and stones built up, into holes dug deep enough to bury all but the head of each statue. I must refer readers wishing for more detailed information to M. Pinart's paper, "Voyage à l'Ile de Paques," *Le Tour du Monde*, 1878, p. 225, No. 927, for drawing my attention to which I am indebted to the librarian of the Royal Geographical Society, Mr. Rye.

The population of Easter Island was by some earlier voyagers estimated at as high as 1,500. It may have been greater, and as many as 500 men would certainly not be required for the erection of any of the images. There was undoubtedly a good deal of wood in the island in old times, and thus rollers and levers would be made use of. The trees of the island have now been exterminated by the inhabitants. Palmer speaks of a peculiar gesture of the modern Rapanui natives which he compares with certain features in the images. It is the opinion of experts that the general appearance of the sculptured faces is decidedly Polynesian, as far as mode of artistic treatment is concerned. Mr. Mott's conclusion that the existence of these images proves that a nation formerly existed which navigated ships to Easter Island at regular intervals, and kept the place going as a colony, will be regarded as simply absurd by any one who knows anything of the science of navigation. So small and so isolated an island as Rapanui could only be reached by navigators who had a very advanced knowledge of astronomy and navigation, and were provided with instruments of great precision, and who had determined the position of the island on maps with exact correctness. No Chinese, Japanese, Indian, or Arab navigators could have hit on the island except by accident. An exact determination of longitude, as well as of latitude is involved in the matter. A mere knowledge of the compass with even as good information concerning its variations as we now possess would not avail. The island was discovered by Roggeveen on April 5, 1722; in 1764 Commodore Byron, with two ships, sought for the island in vain; in 1766 Bougainville, with two French ships of war, sought for it also in vain; in 1767 Capt. Cartaret made the same attempt with a similar result. It was only on March 11, 1774, that Capt. Cook found the island again, and Mr. Mott would have us believe that persons who were by the undoubted evidence of their artistic capabilities and method of treatment of the human figure in sculpture, savages, were able to accomplish, as often as they wished, a feat of navigation which baffled some of the best European navigators of the eighteenth century. Even at the present day so difficult is the determination of longitude to persons not specially trained as expert navigators that the island of Bermuda, and even the Virgin Islands have been more than once reported as "gone down" by merchant captains who could not find them.

With regard to Mr. Mott's "gentle protest" against my statement that "the accepted scientific position is that primitive man was savage," no protest, whether gentle or otherwise, will alter the fact that such is the case; but it is quite superfluous to enter into a discussion here on the general theory of evolution, in accordance with which that position is maintained.

H. N. MOSELEY

Silurian Fossils in the Curlew Mountains

I BEG to state that the paragraph which occurs in NATURE, vol. xx. p. 641, that Silurian fossils have been found in beds amongst the Curlew Mountains "supposed to be old red sandstone," is not quite correct. It was very well known in this office that the beds containing the fossils were of the Silurian formation—though erroneously included within the boundary line of the old red sandstone in the Survey Map, sheet 76. Since the map was engraved, the district to the north and east has been surveyed, and a large fault was discovered, ranging in the direction of the spot where the Silurian fossils have been found. The occurrence of this fault explains the presence of the beds with Silurian fossils within the area of the tract coloured as old red sandstone. There is, therefore, nothing in the announcement in your paper of the slightest novelty, and I have only to state that if the writer

of the paragraph had communicated with myself previously to "rushing into print," he would have received such information as would have prevented him giving publicity to a statement which however literally correct, is erroneous in essence.

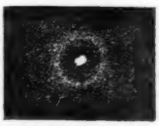
EDWARD HULL,
Director of the Geological Survey of Ireland

Geological Survey of Ireland, Dublin, November 6

[We were indebted for the note to the courtesy of Mr. Kinahan, of the Geological Survey of Ireland.—ED.]

Lunar Ring

WHILE experimenting on the actenic power of lunar light on August 30 last (period of full moon), at 9.30 P.M., I obtained, with a minute-and-a-half exposure, a photographic negative of the moon, which shows a distinct and well-defined ring or glory around it which was not visible to the naked eye on looking directly at the moon in a clear and cloudless sky, nor was there any halo on the ground glass of the camera, nor on the lens, at the time of observation This is a copy of it from the negative.



I used no clock-work arrangement with the camera, but allowed the moon to traverse the plate, and I have since then taken several photographic observations under various conditions. I have taken the moon in all her phases, with long and short exposures, in clear and cloudless sky, and never could get a ring even faintly defined. I have also heated the camera and screwed the cold lens into it, carried it into a colder atmosphere in order to produce condensation of dew. I have placed two small separate openings in front of the lens; on one occasion I dusted puff-ball spores upon the lens; on another I breathed warm breath upon it, but never got anything but decided burr, which was always densest near the limb of the moon and gradually tapered away towards the circumference like a bright light seen through a thick fog, but no appearance of ring. I have also taken observations when scud was passing rapidly over the moon, when perfect prismatic halos were visible to the naked eye, but no ring was ever impressed on the photographs; nothing more than a haze, such as that produced by breathing on the lens. The next full moon (September 29) was totally obscured, so that I failed to get an observation then; but last evening (October 29), at 10 P.M., I was fortunate to get one fine, clear exposure of one-and-a-half minute, and was pleased to see a clear and well-defined ring rise up on the plate during development, similar in every respect to that obtained on August 29, showing clearly that this unusual appearance is dependent upon the position of the moon in her orbit, she being in opposition when she manifests ring-giving power and shows us a crown. But why is this? What is the cause of this unusual, and, I believe, hitherto undescribed, appearance? Why should this ring be invisible to the naked eye and yet give a luminous impression on a photographic plate? Why should it appear only at full moon period and not at any other phase? Can it have any connection with what Mr. Newall saw round Mars through his huge telescope? If the moon had an atmosphere similar to that of the earth, and a star of some magnitude were occulted by the moon at that particular time, it is possible that its light in passing through the lunar atmosphere might be refracted so as to show a corona round the moon; but it is pretty generally acknowledged that there is no atmosphere surrounding it, therefore there can be no refraction.

It might be that the solar rays in passing through the upper regions of the earth's atmosphere are so defracted that the ultra-violet rays (though invisible) are thus rendered visible.

It is also possible that the doubly-reflected lunar light (the ashy light), in passing back to the moon from the earth, encounters on its passage the reflected solar rays from the moon, arresting and nullifying in proportion to its strength, so much of the light proceeding from the moon thereby causing a clear space around the moon-limb, a region of inertia, while the reflection from the disk of the earth, being larger than the moon's reflecting disk, will show itself as a ring on the outer edge of the neutral zone, much in the same manner as two heliographic reflectors would act if they were so arranged as to throw their respective reflections directly into and upon each other, the one being small and the other larger, just as the moon is the smaller and the earth the larger body, the smaller body reflecting a smaller, brighter light, while the larger body would reflect from its broader disk a less brilliant light with a feebler force, yet not so feeble as to prevent it arresting an amount of force equal to itself.

GEORGE BERWICK

Sunderland, October 30

[Dr. Berwick's explanation appears scarcely sound for it involves the assumption that a ray of light meeting another can arrest it; and also it involves the visibility of such rays while traversing space. We would remark that faint halos due to atmospheric causes are often seen almost masked by the brightness of a full moon, and the photograph being over-exposed, so far as the moon is concerned, does not show the relative actinic brightness of moon and halo. Would Dr. Berwick try further experiments with shorter exposures, and also ascertain from a number of photographs how far on either side of full moon a halo can be photographed, and whether it is always present during similar periods?—ED.]

Phosphorescence

A FEW days ago my attention was drawn to the phosphorescence of some fish (haddock) just received from the coast. The light was most brilliant about the fins and inside of the fish, which had been gutted. A spectroscope of low dispersive power showed all the light to belong to the green part of the spectrum. Approximate measures gave 557·5 (mm.) and 488·4 as the extreme wave-lengths, the part from 557·5 to 503·4 being somewhat brighter than the remainder, with a feebly indicated maximum at 527·6.

In the hope of getting a brighter spectrum the fish were washed in as small a quantity of water as possible. This water became highly phosphorescent, and when agitated in a bowl, gave beautiful luminous caustics, but neither in the bowl nor in a glass trough, nor in a tube of half-inch bore, did the liquid give a brighter spectrum than that afforded by the fish.

A large bubble of air was inclosed with the liquid in the tube. When the tube was violently agitated, it became luminous from end to end; if then held vertically, the light rapidly faded except near the top of the liquid, but on suddenly inverting the tube, the bubble of air slowly ascended, causing the whole contents of the tube to phosphoresce very brilliantly. This was a most striking phenomenon. After the lapse of some nine hours, the liquid had almost entirely lost the power of giving light.

The Observatory, Dunecht, Aberdeen, November 5

RALPH COPELAND

The "False Dawn"

FOR some time past certain considerations had led me gradually to infer that the "False Dawn" of the very extensive literature of Islām, whether Arabic, Persian, or Turkish, &c., and whether prose or verse, is another name for the "Zodiacal Light." No dictionary yet published so explains it.

I submitted my ideas and reasons to a number of English and foreign astronomers and linguists. All expressed their concurrence in those views; but direct proof of their correctness was not at once forthcoming. Recently, however, through the kindness of the Hydrographer to the Admiralty, a most obliging effort was made to solve this question by Capt. Wharton, commanding H.M.S. *Fawn*, now cruising in the Sea of Marmora. The method employed by that officer, and its conclusive result, cannot be better described than by giving his own words as follows:—

H.M.S. *Fawn*, Tuzla Bay,
September 26, 1879

Dear Capt. Evans,

For the information of Mr. Redhouse, I have to tell you that I can satisfactorily answer his question as to the false dawn of the Turks.

On the morning of the 20th instant, at 3.30 A.M., I went to a mosque at Buyukdere, and interviewed the Imaum, who, on being asked for the "fejri kyāzib,"[1] at once pointed out the zodiacal light, then brightly shining in the east. . . . There can be no doubt as to the coincidence of the two.

Yours sincerely,
W. J. L. WHARTON

[1] "Fejri Kyāzib" is the Arabic expression for "the false dawn."

This preliminary philological question being thus irrefragably settled, I wish to bring to the knowledge of English and western astronomers the fact that, though the zodiacal light was first distinctly noticed in England in 1661, and named in France by Cassini, in about 1683, the "false dawn" was known to the Arabians in the days of Muhammad, who is said by the commentators in the 183rd verse of Chap. II. of the Qur'ān, to have there legislated on the subject as follows, when he instituted the diurnal fast of the Ramazan in the second year of the Hijra (A.D. 624):

"And eat and drink until the lighter streak of the dawn shall become distinguishable unto you from the darker streak."

Commentators, and, after them, the most highly esteemed Arabic dictionary, the Sihāh of Jawhari, who died in A. H. 397 (A.D. 1006) explains the expression "the lighter streak," as meaning "the true dawn," and, "the darker streak" as signifying "the false dawn."

Here, then, is incontrovertible proof that the zodiacal light, under its Arabic name of "the false dawn" was explicitly mentioned 650 years, and implicitly, 1,000 and odd years, before western observers had noticed the phenomenon. This is a point deserving special consideration by all who may in future write a history of the progress of discovery in respect to the zodiacal light. To how much older a time than that of Muhammad, a knowledge of the light may be hereafter traced, is a question that I leave with confidence to those who so fruitfully investigate the fragmentary records of antiquity. I should imagine that no one will suppose Muhammad was the first to take notice of an appearance that is, at times, much brighter than the "milky way."

Another suggestion has also arisen in my mind, of a far wider interest, in connection with my discovery. It is this:—

Modern western Sanskrit scholars have inclined to the idea that the high *plateau* of Pamir, which separates Chinese from Independent Tartary, and the Indus from the Jaxartes, was the primeval cradle of the whole Aryan race. Physically and historically, this hypothesis seems to be utterly untenable, though my reasons would be out of place here. The zodiacal light would appear to confirm my objection.

From the latitude of Pamir, the zodiacal light is a very conspicuous object there, and sure to be noticed by a nation of shepherds, nomads, warriors, and commercial caravan travellers. Had the various Aryan races all come from Pamir, they would have brought thence a knowledge of the zodiacal light, as they all brought the word "yoke" with them from the land whence they radiated. How comes it, then, that in ancient times as in modern, no Aryan, not even after Alexander had nearly reached Pamir, and the Ptolemies had reigned in Egypt for centuries, ever observed or mentioned this phenomenon? My conjectural answer is this: The Aryan race came originally from a northern land, where the zodiacal light is rarely and but dimly visible, radiating from thence as they have done all through the historical period, and as their rearmost representatives, the Slavs, are persistently striving to radiate still to climes more favoured than their own.

J. W. REDHOUSE

London, November 5

The Caudal Disk

THE following may throw some light on the use of the caudal disk possessed by many of the Uropeltidæ (*vide* NATURE, vol. xx. p. 538):—

When in the Wynaad, in September, 1875, I captured, at the foot of the Nilgiri Hills, a Silybura, referred, I think, by Col. Beddome to the species, Nilgiriensis. This snake I took down to Mangalore, and kept alive until the succeeding March, when it was unfortunately killed by ants. When caught it was working its way through grass by the road-side, and made violent efforts to escape, striking my hand repeatedly with the pointed terminal scales, by throwing back its tail. I am uncertain whether to view this action as defensive or not. It may have been the result of the snake's struggles, but it is noticeable that the movement was vertical and not horizontal.

I had but few opportunities of investigating the matter, for in a few days the snake became so used to being handled that it would make no efforts to escape.

It was kept in a box filled with earth to the depth of some six inches, and during day-time never was to be seen, but at night came to the surface regularly, and was then much less sluggish than in the day. When taken out of the earth, it would at once commence to bury itself by forcing its pointed snout downwards, and alternately expanding and contracting the thick anterior portion of the body. The motion was exactly that of a worm, and the posterior portion of the body and the tail were dragged slowly after by longitudinal contraction, and were not actively used. During the burrowing process there were occasional pauses of that part of the body above ground, but from the movements of the earth it was evident that the snake was still progressing. So sensitive was the skin that the gentlest breath would hasten the withdrawal of the body, but so soon as the caudal disk was level with the surface the snake would retain it in that position for a long time, sometimes half an hour and more. The numerous keels on the scales of the disk carried a certain amount of earth; the disk invariably remained in the same plane as the ground's surface, exactly filling the hole, and it was therefore almost impossible to detect the snake, without close examination.

These facts suggested to me the idea of the disk being protective, and I therefore, on numerous occasions, unearthed the snake and watched it burrow, always with the same result—the steady withdrawal of the sensitive portion of the body, and the retention of the disk at the surface for a longer or shorter period.

I do not know what are the chief enemies of Uropeltidæ, but possibly certain carnivorous birds prey on them. If so, it is conceivable that the earth-covered disk would secure the snake and its hole from observation, until the head had worked sufficiently far underground to admit of the tail being at once withdrawn, beyond reach of beak or claw. This is quite possible from the power these snakes possess of extending themselves, a power well displayed if one of them be held firmly in both hands.

E. H. PRINGLE

P. and O. S.S. *Pekin*, Gibraltar, October

Intellect in Brutes

THE Duke of Argyll in his "Reign of Law" was, I think, the first who promulgated the dictum that man is the only tool-making animal. As far as I can ascertain, this assertion is admitted by developmentists, yet it is undoubtedly true that the Indian elephant makes two *implements*, or forms and alters certain things so as to adapt them specially to fulfil definite purposes, for which, unaltered, they would not be suitable.

One evening soon after my arrival in Eastern Asam, and while the five elephants were as usual being fed opposite the Bungalow, I observed a young and lately caught one step up to a bamboo-stake fence and quietly pull one of the stakes up. Placing it under foot, it broke a piece off with the trunk, and after lifting it to its mouth, threw it away. It repeated this twice or thrice, and then drew another stake and began again. Seeing that the bamboo was old and dry, I asked the reason of this, and was told to wait and see what it would do. At last it seemed to get a piece that suited, and holding it in the trunk firmly, and stepping the left fore-leg well forward, passed the piece of bamboo under the armpit, so to speak, and began to scratch with some force. My surprise reached its climax when I saw a large elephant leech fall on the ground, quite six inches long and thick as one's finger, and which, from its position, could not easily be detached without this scraper, or scratch, which was deliberately made by the elephant. I subsequently found that it was a common occurrence. Leech-scrapers are used by every elephant daily.

On another occasion, when travelling at a time of year when the large flies are so tormenting to an elephant, I noticed that the one I rode had no fan or wisp to beat them off with. The mahout, at my order, slackened pace and allowed her to go to the side of the road, where for some moments she moved along rummaging the smaller jungle on the bank; at last she came to a cluster of young shoots well branched, and after feeling among them, and selecting one, raised her trunk and neatly stripped down the stem, taking off all the *lower* branches and leaving a fine bunch on top. She deliberately cleaned it down several times, and then laying hold at the lower end broke off a beautiful fan or switch about five feet long, handle included. With this she kept the flies at bay as we went along, flapping them off on each side every now and then.

Say what we may, these are both really *bonâ fide* implements, each intelligently made for a definite purpose.

S. E. PEAL

A COCHIN-CHINA REMEDY FOR LEPROSY

A NOTE in NATURE (vol. xxi. p. 19) refers to a remedy for leprosy, obtained from Cochin-China, but the origin of which is imperfectly known. Its name is given as *hwang-nao*. In Mr. Consul Tremlett's Report (For. Off. Repts. No. 21, p. 1237) it appears as *hoang-nau*. We have taken a good deal of trouble about this drug at Kew, and the inclosed extract from the Kew Report for 1877, p. 31, contains all that has been positively ascertained about it at present:—

"*Hoâng-nan, a Supposed Remedy for Leprosy.*—Mr. Prestoe, Superintendent of the Trinidad Botanic Garden, has drawn my attention to some accounts given in *Les Missions Catholiques* for 1875, describing the surprising efficacy of a drug, the produce of a plant found in Cochin-China, in the treatment of leprosy and rabies. The plant is known by the name of Hoâng-nan, and the description, which is of the vaguest kind, represents it as a climber, and its bark as the efficacious portion.

"M. L. Pierre, the Director of the Botanic Garden at Saigon, has obtained an imperfect specimen of the Hoâng-nan, and informs me that he identifies it as a new species of *Strychnos*, which he has named *S. gautheriana*, in honour of the ecclesiastic who first gave the virtues of the Hoâng-nan a wider publicity.

"M. Pierre adds some remarks which appear to me worthy of placing on record:—'The bark of *Strychnos nux-vomica* is regarded in Cambodia and Siam as a poison no less certain than that extracted from the seeds. The natives have remarked the fact, which is also believed to hold good in the case of cinchonas, that the bark has the most powerful properties when it has been covered with moss or otherwise protected from the action of light.' In collecting the bark great attention is paid in consequence to the circumstances under which it has been produced."

W. T. THISELTON DYER

SOME POINTS IN THE HISTORY OF SPECTRUM ANALYSIS[1]

A PHYSICAL problem begins like a rivulet. At its first introduction it is small and seemingly unimportant—constantly however, as it winds along it receives accessions from various quarters until at length it becomes a mighty river that is finally merged in the unfathomable ocean. This course is followed by all such problems. Each begins small—grows broader and will finally bear us on to the unknown if we trust ourselves to its guidance.

I need hardly remind you that the demonstration of the decomposition of white light was one of the triumphs of the illustrious Newton. But like other problems it had its small beginning. We find in one of the earliest memoirs of the Royal Society, a paper on "The Genuine Method of Examining the Theory of Light and Colours," by Mr. Newton. Here he asks amongst others, the following questions:—

(1) Whether rays that are alike incident on the same medium, have unequal refractions?

(2) Whether rays endued with particular degrees of refrangibility, when by any means separated, have particular colours constantly belonging to them, viz., the least refrangible scarlet, the most refrangible deep violet, the middle sea green; and others other colours?

(3) Whether colours by coalescing do really change one another to produce a new colour, or produce it by mixing only?

(4) Whether a due mixture of rays, endued with all variety of colours, produces light perfectly like that of the sun? and he ends by remarking that the most proper and direct way to a conclusion is to determine such queries by experiment. Then follow some objections to the theory of light and colour, by the Rev. F. Pardies and Mr. Newton's reply to these objections. Into the nature of these however, it is not my purpose to enter. Let me rather adopt Newton's suggestion and bring the experiment itself before you.

[1] Being an address delivered by Dr. B. Stewart, F.R.S., at the opening of the present session, to the Natural Philosophy Classes at Owens College.

You are all, no doubt, familiar with the operations of the photographer, and as a matter of fact you know that when the light from a natural object is made to pass through his lens an image of this object is impressed upon the sensitive plate placed at the focus at the other side of the lens.

If the natural object be a friend's face you obtain his photograph, if it be a tree, you get the image of the tree, if it should be a bright slit of light or a bright wire you would get the image of the slit of light or of the wire. Now here we have a slit which is rendered luminous by an intense light thrown upon it, and if we place a photographer's lens before it we shall obtain an image of the slit. You see the image thrown upon a screen and you see moreover that the light is white; it is in fact the electric light which illumines the slit. For the machine by which this light is produced our college is indebted to the generosity of Mr. Wilde. But my object is not now to discuss the electric light, but to show you that it is white and like the light of the sun—since, as you see, its image on the screen is white. Let us now interpose a prism or train of prisms between the lens and the screen. These prisms will do two things. In the first place they will bend the rays towards the base or thick part of the prisms so that in order to catch the image the screen must be moved in this direction. But in the second place they will bend some rays more than others;—if the slit be lighted by pure red light it will be least bent, if by orange, this will be more bent than the red, if by yellow this will be more bent than the orange, then follow green, blue, indigo, and violet, the latter of which is most bent.

Now if the light behind the slit be a mixture of red, orange, yellow, green, blue, indigo, violet, we shall have a series of images of the slit overlapping one another, and forming a long ribbon of light of which the portion least bent will be coloured red and that which is most bent will be violet. Let us now see what we get from the light we are using. Here you see we have all the colours of the rainbow, red, orange, yellow, green, blue, indigo, violet, and therefore our light must contain all these; but our light was white like that of the sun and thus you see we are entitled to say that white light is composed of a mixture of these various colours.

In fact what we have done by the prism has been to separate these various constituent rays from one another and throw one on one part of the screen and the other on another part. But now if we make these various constituents to dance so quickly before our eyes that we get a united impression of the whole, we shall imagine once more that we have white light. We separated the rays in space—let us now combine them in time—and you see the thing is white. We have thus demonstrated the composition of white light after the way by which the chemist proves the composition of water, first decomposing it by the battery into oxygen and hydrogen, and then causing these two gases once more to recombine. I will now remind you that light consists of waves or undulations given out by the luminous body. These waves take place in a medium called ether, surrounding us all, in which they proceed with incredible swiftness. The light given out by a luminous particle may thus be compared to the note or notes given out by a bell. In solids and liquids however the particles are so closely packed together that they may be likened to a number of different bells all tied together in such a way that the total mass is capable of giving out every, or almost every, variety of note. From an incandescent solid or liquid body, when sufficiently hot, you thus get every variety of light, and

it is particles of carbon, probably in the solid state, that in the electric light afford us every variety of ray so as to enable us to get from them a continuous spectrum. When, however, we go from solid and liquid particles to those of a gaseous nature, we find the various molecules so far apart that each one is unconstrained by its neighbour; it is thus like a bell left to itself, in which case it gives out its own peculiar kind of light just as a bell, left to itself, will give out its own peculiar note. I will now show you on the screen the various rays or luminous notes given out by particles of incandescent vapour of silver.

We thus see what is the spectroscopic difference between solids or liquids, and gases, the former when sufficiently heated giving out a continuous spectrum consisting of all different rays of light, the latter a discontinuous spectrum consisting of only a few different rays.

The next point to which I will call your attention is a very important one. A particle when cold or comparatively cold absorbs those very rays which it gives out when hot. Now it is known that incandescent vapour of the metal sodium, gives out under certain conditions a peculiar monochromatic yellow light, which we call the double line D. This light is so strictly monochromatic that all bodies under its illumination appear either yellow or black, as you will see by the following experiment.

Now suppose we take the electric lamp, the carbon points of which, as you already know, give out all kinds of light, and suppose we place between these points a piece of metallic sodium; while this sodium is in the act of being volatilised, and its vapour comparatively cold, you will see that it will stop one particular kind of light, and will thus cause a black line. When, however, the vapour is sufficiently hot, this black line will be changed into a bright yellow one. You thus see that when we have an incandescent body which gives us all rays, and when between it and the eye we insinuate some comparatively cold sodium vapour, we get a certain definite black absorption line.

Now the curious point is that the sun's light gives us this black line, so that if I could replace the electric light by the sun, I should have a black line thrown upon the screen in the very position where you saw it when the sodium was introduced.

This means that between the source of the sun-light and the eye, we have sodium vapour in a comparatively, remember only comparatively, cold state, and as this vapour is certainly not in the earth's atmosphere, it can only be in the atmosphere of the sun. I need not tell you that although colder than the particles beneath it which give us sun light, it must be in reality very hot. The discovery that there was vapour of sodium in the atmosphere of the sun was due to Stokes, and it has since been found out by Kirchhoff that we have black lines in sun light corresponding in position with the bright lines of iron vapour, the bright lines of hydrogen, the bright lines of magnesium vapour, and the bright lines of many other elements, and we may therefore assume as Kirchhoff assumed, as a first and approximative hypothesis, that the vapours of iron, magnesium, hydrogen, &c., as well as that of sodium exist in a comparatively cold state in the atmosphere of our luminary;—more recent work by Huggings and others has shown that the same remark applies to the atmospheres of many other stars.

You thus see that there are two ways by means of which the chemical composition, or rather perhaps the atomic structure of bodies may be indicated by the spectrum. At a comparatively low temperature this structure will be indicated through the lines that are absorbed or rendered black, while at a comparatively high temperature it will be indicated by the bright lines that are given out.

Thus at a comparatively low temperature a solution which contains blood will indicate the presence of this substance by certain very peculiar black lines. Blood, however, is easily decomposed by a high temperature, and accordingly when such is applied we no longer get the bright equivalents of these black lines, but something very different, namely, the bright lines of iron, and of those other elements into which blood is decomposed as the temperature is raised. In short when raising the temperature of a substance its black lines will be converted into bright ones only in those cases where no molecular change has taken place between the two temperatures. Even in the case of elements like sodium Roscoe and Schuster have shown that the absorption spectrum at a low temperature is different from, and more complex than, the radiant spectrum at a high temperature, and other elements have been tried in this way by Lockyer and others with similar results. We may imagine with much propriety that the molecule of sodium vapour at a low temperature is a larger and more complex structure than it is at a high temperature, where the splitting up or dissociating agency of heat has been freely employed.

We come at last to the important question which it is my object to discuss. Has a study of the spectrum thrown any light on the ultimate constitution of matter, or is it likely to do so?

You are aware that chemists and physicists have begun to speculate as to the possibility that the so-called elements may be in reality nothing more than combinations differing in numbers and in tactical arrangement, of some one kind of primordial atoms.

This idea was first entertained by Dr. Prout, the well-known physician and chemist. He pointed out that the atomic weights of the so-called elements are very nearly all multiples of the half of that of hydrogen, so that the various elements may possibly be looked upon as formed by a grouping together of certain atoms of half the mass of the hydrogen atom.

M. Stas, the distinguished Belgian chemist, instituted a laborious series of experiments with the view of testing this doctrine. He came to the conclusion that the atomic weights of the various elements were not precisely multiples of the half of that of hydrogen, there being greater differences than could possibly be accounted for by errors of experiment. His researches, however, seemed to show that in many cases there was a very near approach to Prout's imagined law. But here we must bear in mind the great difficulty, or indeed impossibility, of obtaining substances absolutely free from all impurities (indeed Dumas showed that oxygen forms part of the silver with which Stas worked), so that we may be excused from imagining that Stas has settled the point in the negative. We are thus driven to look to the spectrum as a likely means of throwing some light on this very interesting and important speculation.

Let us now, therefore, endeavour to realise what would be the behaviour of the spectrum if the so-called elements were not capable of simplification, and also what would be its behaviour if they were, and then find with which of these two hypotheses the true behaviour of the spectrum agrees best. Now if the elements were absolutely simple bodies, we might still expect that the molecule of vapour of an element would be at a low temperature more complex than at a high one, and would therefore give out a more complex spectrum. As, however, the temperature was made to rise we might expect ultimately to obtain a certain spectrum which would represent the simplest mode of vibration of that element, and which would thenceforward remain, however much higher the temperature should be made to mount. Lockyer has written much on this point and given many facts in support of this view.

And again we should have no reason for supposing that the lines of the ultimate spectrum of one element should coincide in position with those of the ultimate spectrum of another element. If therefore we had a mixture of all the elements, and subjected this mixture to a very high

temperature, the resulting spectrum under the supposition that each element is really an element, would never be simpler than the combined spectra of the various elements.

On the other hand, if the elements were really compounds of some one primordial atom, we might expect that a very high temperature would split up their atomic structure, and simplify their spectra, so that at an enormously high temperature a mixture of all the elements might nevertheless give us a very simple spectrum. We might likewise expect that different elements might split up into common constituents, so that at a very high temperature the spectra of these elements would have certain lines in common.

It is in the larger masses of the Universe, the sun and stars that we must look to find a mixture of all kinds of matter at very high temperatures, and when we have a brilliant bluish-white star containing a large proportion of the more refrangible rays we have every reason for supposing this star to be at a very high temperature. Now such stars exhibit an extreme paucity in the black lines which appear in their spectra, in which there is hardly anything else than certain prominent lines seen in the spectra of hydrogen, calcium, magnesium, and sodium. Lockyer, who has devoted great attention to this subject, argues therefore as follows. If it be true that as a rule the atmospheres of the whiter and presumably hotter stars contain fewer elements and those of the smallest atomic weight and that as stars diminish in whiteness their atmospheres rise in complexity of structure this undoubtedly tells in favour of the power of high temperature to split up the so-called elements. He has quite recently carried this reasoning into another field. The Fraunhofer lines give us the integration of the absorptions of all the strata of the solar atmosphere. Now spot phenomena occur in a restricted stratum of this atmosphere, and this stratum is low and therefore hotter than the overlying portions. We can tell the spectral lines special to a spot by their widening, and the number of lines widened is small in comparison with the Fraunhofer lines. Here again we have simplicity brought about by high temperature in the low levels in the sun as in the stars hotter than the sun.

Let us now ask whether the spectra of the various elements have or have not certain lines in common. It used to be imagined that they had not.

When, however, they have been examined under great dispersive power there has been found reason to qualify this assertion. There are certain lines in the spectra of each element which appear long and thick, their predominant notes as it were, and it has been found that while such a line for instance is exceedingly prominent in some one element other elements appear to possess it, only not nearly so prominently. Lockyer's argument from this was that, on the assumption that the elements are truly elementary, the line in the other elements was caused by traces of impurity. He has, however, recently had reason to believe that there are coincidences between the spectra of the various elements not of this nature. There are coincidences of lines which are not the prominent lines of any one spectrum and they give no signs of that variability of brightness that might be expected to characterise lines due to impurities. These lines he has called basic lines. As may be readily imagined in a branch of knowledge which is so new we shall have long to wait for facts. Hence we cannot test this conclusion by referring to the spectra of stars. But Lockyer has already shown that we can test it by means of the spectra of sun-spots, and here the facts are certainly in support of it. The basic lines are more prominent in the spectra of spots than in the spectrum of the sun generally, and further they are more prominent at epochs of sun-spot maximum than during times of minimum.

But we must have a clear conception of what we mean when we suppose that the so-called elements are split up at a very high temperature.

If we apply a very powerful source of electricity we obtain certain peculiar lines from the vapour of calcium.

Now if we could (like the Demon of Maxwell) catch hold of and segregate—put into a box as it were all these minute entities that give us this suspicious line at a high temperature, and further if we could keep their high temperature up I think it is probable that we might obtain something which is not calcium, or at any rate, something simpler than the molecule of calcium as this appears at lower temperatures. But we are not yet able, and perhaps we may never be able, at an ordinary temperature to present the chemist with some other substance derived from calcium which is not calcium.

To conclude there seems little doubt that spectrum analysis will, as it advances, throw great light on the ultimate constitution of matter and it therefore justifies the remarks which I made at the commencement of this lecture.

THE SWEDISH NORTH-EAST PASSAGE EXPEDITION

DESPATCHES have been received by Mr. Oscar Dickson, of Gothenburg, from Prof. Nordenskjöld, giving an account of the wintering of the *Vega*, down to April 1; letters from Lieut. Palander and other members of the North-East Passage Expedition have also been published, some of them bringing down the narrative to a later date. From these we gather the following particulars:—

The *Vega* was frozen in on September 28, in 67° 7′ N. lat. and 173½° long. W. from Greenwich, at the northernmost extremity of Behring's Straits. The land in the neighbourhood forms an extensive slightly rolling plain, bounded on the south by gently-rising hills, which, farther into the interior, are said by the natives to reach a considerable height. The plain is occupied to a large extent by lagoons separated from the sea by low sandy beaches. When the *Vega* was frozen in, the ground was covered with hoar frost and frozen, but still free of snow, so that it was possible to form some idea of the flora of the region. Close to the beach, compact beds of *Elymus* were intermixed with carpets of *Halianthus peploides*; next there stretched a poor level gravelly plain, only covered with a black lichen, *Gyrophora proboscidea*, and some few flowering plants, amongst which *Armeria sibirica* was the most common. South of this, again, was a tract occupied by lagoons and small lakes, whose shores were covered with luxuriant vegetation, consisting of grasses and *Carices*. On the neighbouring high ground, where the soil, derived from weathered strata of gneiss and dolerite, is richer, the vegetation is marked by greater variety. Here were thickets of willows, extensive carpets of *Empetrum nigrum*, and *Andromeda tetragona*, and large tufts of a species of *Artemisia*. Here were found also the frozen remains of the red whortleberry, the cloudberry, *Taraxacum officinale*, and other plants peculiar to the high north. In an excursion to the interior on October 8, Lieut. Nordquist observed that on the driest parts of the *tundra* the most common plants were *Aira alpina* and *Poa alpina*; on the lower places, *Glyceria*, *pedicularis*, and *Ledum palustre*. *Petasites frigida* and a species of *Salix* occurred everywhere, the latter growing in large compact masses covering spots several hundred square feet in extent, the bushes in some places being 3 to 4 feet high.

In the neighbourhood of the *Vega's* winter quarters there were six small encampments, numbering from three to twenty-five tents each, inhabited by Tchuktches to the number of about 200. With these natives there was much friendly intercourse. They were allowed free access to the deck from which, though covered with a multifarious

variety of articles, they did not remove the smallest trifle. They were not, however, altogether to be depended on in the statements they made regarding the articles they offered for sale. Thus, on several occasions what were represented to be hares were found to be dead foxes skinned and with the head and feet cut off, and the natives expressed great astonishment at the instant discovery of the deception. When they had acquired a taste for European food, they bartered drift-wood and the bones of the whale for ship-biscuit, and the quantity distributed partly in this way, partly as gifts, was so considerable as to contribute in no small degree to mitigate the famine that threatened to break out among the natives in mid-winter. None of them were Christian, nor could any of them speak any European language, except one or two who could say a couple of words in English or a word of salutation in Russian. Lieut. Nordquist studied their language with such zeal and success, that in a fortnight he could make himself pretty well understood. He has collected materials for a comprehensive vocabulary.

When the *Vega* was frozen in, the sea next the coast was covered with newly-formed ice, too thin to carry a foot-passenger but thick enough to prevent a boat from making any way. On October 3 the Tchuktches walked on board over the ice. Up to the 10th there were weak places between the vessel and the land, and a blue sky in the east still indicated open water in that direction. On the 13th it was ascertained that a belt of drift ice-fields, compactly frozen together, at least thirty kilometres in breadth, lay between the *Vega* and the open sea. The thickness of the newly-formed ice was measured by Lieut. Bruzewitz, with the following results:—

The Thickness of the Ice

On December 1	56	centimetres.
„ January 1	92	„
„ February 1	108	„
„ February 15	120	„
„ March 1	123	„
„ April 1	127	„
„ May 1	154	„
„ June 1	154	„
„ July 1	103	„

For a distance of about six kilometres from the shore the ice lay all winter nearly undisturbed, but farther out it was in continual motion. So-called polynia, or open places, says Nordenskjöld, probably occur here all the year round, and in favourable weather accordingly we could see almost constantly a blue water-sky from true north-west to east. A southerly wind in a few days brought the open water within a few hours' walk of the vessel. It then swarmed with seals, which indicates that it was in connection with a sea always open. The neighbourhood of such an open sea probably accounts for the fact that in the fields of drift-ice that surrounded the vessel there was not a seal-hole to be seen. On January 1 Lieut. Bove reached open water by a four hours' walk. From the fact that from a hummock five metres high he could see no boundary to the open water towards the north-east and north, and from the extent of the water-sky in that direction, he concluded that the breadth of the open water was at least thirty-five kilometres. The depth at the edge of the ice was twelve fathoms, the temperature $-2°$ C. The water ran at a considerable speed right from the coast (from south-south-east), apparently a tidal current. The open water swarmed with seals. No polar bear, no walrus, and no birds were seen.

During the long-continued severe cold in the month of January, in the course of which the temperature several times fell below the freezing-point of mercury, the sea appears to have frozen completely for a great distance from the coast, but by February 7 mild weather again commenced, with variable and southerly winds. The same day a faint water-sky was seen at the horizon. Some kilometres to the east the beach was free of ice, and from the heights on land the seamen observed a high sea in the blue streak of water which bounded the horizon. The open water thus appears to have been very extensive. The statement of the natives that it extended to Behring's Straits was perhaps correct.

The temperature during the wintering was as follows:—

	Minimum. °	Maximum. °	Mean. ° C.
October	− 20·8	+ 0·8	− 5·21
November	− 27·2	− 6·3	− 16·59
December	− 37·1	+ 1·2	− 22·81
January	− 45·5	− 4·1	− 25·05
February	− 43·8	+ 0·2	− 25·08
March	− 39·8	− 4·2	− 21·65
April	− 38·0	− 4·6	− 18·93
May	− 26·8	+ 1·8	− 6·97
June	− 14·3	+ 6·8	− 0·60

On two occasions the barometer was uncommonly high, viz.,

December 22, 6 A.M. 782·0 (0°) mm.
February 17, 6 A.M. 788·1 (0°) mm.

The lowest atmospheric pressure observed before April 1 was on

December 31, 2 A.M. 728·8 (0°) mm.

The weather during the winter was exceedingly stormy, and the direction of the wind near the surface of the earth was almost constantly between north-west and north-north-west. But in a stratum of air at no great height there prevailed, to judge from the motion of the clouds, a similar uninterrupted current from the south-east, which when it occasionally sank to the surface of the earth, brought with it heat and comparatively dry air. This is explained by Behring's Straits forming a gate bounded by high hills between the warm atmospheric area of the Pacific, and the cold area of the Arctic Ocean. The winds must here arrange themselves approximately according to the same laws as the draught in the door-opening between a warm and a cold room. The cold stream of air must go below, and the warm above. The mountain heights which the natives say are to be found in the interior of the Tchuktch Peninsula, besides, contribute to the heat and dryness of the southerly and south-easterly winds. For they give to the winds which pass over their summits the properties of the "föhn." The coldest winds have come from south-west to west, that is, from the Siberian Plain. On the existence of two currents of air which, at a certain height above the surface, contend with one another for the mastery, depends again the speed with which the sky in the neighbourhood of Behring's Straits suddenly becomes cloudy and again completely clear.

Nordenskjöld remarks that the fall of snow was not particularly great, but as there was no mild weather of any continuance during the winter, so that the snow was never covered with any continuous crust, a considerable portion of the snow remained so loose that it was carried backwards and forwards by the least puff of wind. With a storm or strong breeze, the snow was carried to higher strata of the air, which was so filled with the fine particles, that it was impossible to distinguish objects at the distance of a few yards. But even when the wind was light and the sky clear, there went on a constant snow-storm a few inches in height along the surface of the ground in the direction of the wind, and so principally from north-west to south-east, carrying an immense mass of water in a frozen state over the north coast of Siberia to more southerly regions, and playing a sufficiently important part in a climatic respect, among others as a carrier of cold to the most northerly forests, to deserve the attention of meteorologists.

The most remarkable observations which the wintering of the *Vega* has yielded appear to relate to the aurora. Our voyage happened in one of the years, writes

Nordenskjöld, of which it was known beforehand that it would be a minimum aurora year. Just this circumstance has, however, allowed me to study, in a specially suitable region, this natural phenomenon under uncommonly favourable circumstances. For here the luminous arches, which also in Scandinavia generally form the starting-points of the ray-auroras, have shown themselves undimmed by the more splendid forms of the aurora, and one could thus devote one's self to collect observations towards a clearing-up of the right nature of these arches undisturbed by accidental accompaniments. Referring for details to a paper he has sent home for publication in the *Transactions* of the Swedish Academy of Sciences, he goes on to say that the aurora, during the winter 1878-79 never appeared with the splendid bands or draperies of rays so common in Scandinavia, but always in the form of faint luminous arches, which remained unaltered in position hour after hour and day after day. They were *constantly* visible when the sky was not clouded nor their feeble light dimmed by the rays of the sun or the full moon. The conclusions Nordenskjöld draws from numerous measurements of the height, extent, and position of these arches are, that our globe, even during a minimum aurora year, is ornamented with a nearly constant corona or circle of light, single, double, or multiple, whose inner edge during the winter of 1878-79, had a height above the surface of the earth of about $\frac{3}{100}$ of the earth's radius, whose centre, the "aurora pole," was situated on the radius of the earth which touches the surface about 81° N. lat. and 80° W. lat. (Greenwich), and which, with a diameter of 0·3 of the earth's radius, extended itself in a plane at right angles to the radius of the earth which touches the centre of the circle. This circle of light stands in the same relation to the ray- and drapery-auroras of Scandinavia as the trade-winds and monsoons in the south to the irregular winds and storms of the north. Its light is never distributed into rays, but resembles that which passes through obscured glass. When the aurora becomes stronger the extent of the circle of light is altered, double or multiple arches are visible, generally lying in the same plane and with a common centre, and rays are thrown out between the different bows. Arches are seldom seen lying irregularly to or crossing one another. The area within which the *common arch* is visible (on the supposition that it can no longer be distinguished when its altitude is only 4° above the horizon) is bounded by two circles drawn upon the earth's surface with the aurora pole as the centre, by radii revolving round it at angles measured on the earth's circumference of 8° and 28°. It touches only to an inconsiderable extent lands inhabited by peoples of European origin (the northernmost part of Sweden, Norway, Finland, Iceland, and Danish Greenland), and even in the middle of this area there is a belt passing over the middle of Greenland, the south of Spitzbergen, and Franz Joseph's Land, where the *common bow* commonly forms only a faint "veil" of light in the zenith. This belt separates the regions where the luminous arches are seen mostly on the southern from those where they are seen mostly on the northern horizon. In the area nearest the aurora pole only the smaller, in the middle of Scandinavia only the larger and less regularly formed coronas are visible. But in the last-mentioned region, as in Southern British America, the aurora-storms and the ray- and drapery-auroras become common. The region where the aurora occurs in its most developed state is to be sought for near the circle which, with the aurora pole as a centre, is drawn on the surface of the earth with a radius at an angle measured at the earth's circumference of about 24°.

The tidal observations, when compared with other series made in the Arctic seas, give important indications regarding the distribution of land and sea in the Polar basin. The greatest range at the *Vega's* winter-quarters was only eighteen centimetres, which shows that the sea north of Behring's Straits forms a marine basin of limited extent, connected with the ocean only by sounds. The variations in the height of the water, produced by winds, were much greater. They amounted nearly to two metres. Still greater irregular changes in the position of land and sea appear to have occurred within the memory of man. For the Tchuktches were at one time afraid that the Swedes would cause inundations along the coast. This appears to show that the sudden changes in the position of the earth which are well known in the volcanic regions farther south had extended so far noth. As most of the Tchuktch villages are situated close to the sea, one of the mighty waves which earthquakes give rise to would completely destroy an immense number of them.

The magnetical observations made during the wintering, in an observatory built of ice and snow, which, being necessarily on land, was at a very inconvenient distance from the vessel, consisted of (1) absolute determinations whenever opportunity offered; (2) observations of the changes in the strength and direction of the magnetic forces made along with necessary absolute determinations every hour between November 27 and April 1; (3) five-minute observations on the 1st and 15th of every month from and including January 15.

With reference to the natural history of the region in which the *Vega* wintered, Prof. Nordenskjöld states that it is very poor in the higher plants and fungi, but lichens are abundant. The number of insects and other invertebrate land animals was very small. Land- and fresh-water mollusca were completely wanting. Of coleoptera only twenty species were found, belonging principally to the families *Carabi* and *Staphylini*, with two *Curculiones* and *Chrysomelæ*, and the other orders appeared to be equally poor, with the exception, perhaps, of the *Diptera* and *Podurida*. On the other hand the sea-bottom, though covered with a stratum of water always about 2° C. below the freezing-point, swarmed with a large number and a great variety of the lower animal types, of which the dredging-boat almost daily made a rich collection in the channel, which opened early in summer in the neighbourhood of the vessel. Prof. Nordenskjöld expected that the same avifauna would be found with little variation in all the Polar lands. Experience has, however, shown that this is by no means the case, the Tchuktch peninsula being quite an exception. Birds here occur in much fewer number, but in a much greater abundance of types than in Novaya Zemlya, Spitzbergen, and Greenland, and the bird-world in its entirety has thus quite a different stamp. The birds common on Greenland, Spitzbergen, Novaya Zemlya, and the coast of North-west Siberia, *Larus glaucus*, *eburneus*, and *tridactylus*, *Harelda glacialis*, *Somateria spectabilis*, *Plectrophanes nivalis*, *Phalaropus fulicarius*, and *Tringa maritima*, the common raven and several other species, are found here. But in addition to these the following uncommon birds are met with:—The American eider, the common eider, *Somateria mollissima*, being absent; a greyish-brown goose with bushy yellowish-white feathers round the neck; a swan-like goose, white with black wing-feathers, a species of *Fuligula* marked in white and green with a fine black-velvet head, the beautifully-marked, uncommon *Larus Rossi;* a little brown snipe with a bill widened spoon-like at the point; several beautiful singers, among them *Sylvia Eversmanni*, which for some days visited the coast in great flocks, probably on their way to breeding-places farther north, or waiting till the bushes in the interior should be free of snow. A portion of the purely Scandinavian species here exhibit some variations in colour-marking and size.

The mammalia are also more numerous than in other places visited by the Swedish expeditions. According to Lieut. Nordquist the most common mammal is the hare. It differs from the common Scandinavian mountain hare by its greater size (its weight often rising to

14 lbs.) and by the nasal bone not diminishing so rapidly in size. The mountain fox (*Vulpes lagopus*, L.) is very common. The common fox (*Vulpes vulgaris*, Gray) appears also to be common. A red fox, shot in October, differs considerably from the common, and approaches the mountain fox in several particulars. The fox's food during winter appears to consist of hares, ptarmigans, and lemmings. Of lemmings three species were met with, *Myodes obensis* (the most numerous), *M. torquatus*, and *Arvicola obscurus*. The Tchuktches state that a little mouse also occurs, which Nordquist supposes to be a *Sorex*. The two lemmings often showed themselves above the snow during winter, which was not the case with *Arvicola obscurus*. The wolf was seen only twice. The wild reindeer was also uncommon, traces of them having been seen only once. Traces of the land-bear were also seen, and the natives stated that they were not uncommon in summer. The marmot (*Arctomys*) occurs in abundance. An animal described by the natives as living by the banks of streams is supposed to be the common otter. Two weazel-skins were obtained from the natives. It is not certain whether the ermine occurs there. Only two marine mammals have been seen during the winter, the Polar bear and the ringed seal (*Phoca fœtida*). The latter is caught in great numbers, and along with fish and various vegetables forms the main food of the natives. Of land birds there winter in the region only three species, viz., *Strix nyctea*, *Corvus corax*, and *Lagopus subalpina*. The last-mentioned is the most common. On December 14 two large flocks of ptarmigan, one numbering about fifty, were seen about ten miles from the coast. The raven is common at the Tchuktch villages. Its first egg was obtained on May 31. The mountain owl was seen for the first time on March 11, but according to the natives, it is to be met with all winter. In open places on the sea there occur during winter, according to the natives, two swimmers, *Uria Brünnichi* and *Uria grylle*. Besides these there possibly winter on the sea a species of *Mergulus* and one of *Fuligula*, a specimen of the former having been obtained on November 3, and of the latter on March 9.

(To be continued.)

GALILEO AND THE APPLICATION OF MATHEMATICS TO PHYSICS[1]

TWO hundred and ninety-eight years ago to-day (November 5, 1581) Galileo Galilei, then a boy between seventeen and eighteen, matriculated as a medical student in the University of Pisa. At that time Medicine was perhaps the least satisfactory of scientific studies, and though his family had influential professional connections, the empirical maxims and the semi-metaphysical reasons by which they were supported never caught the young man's fancy or satisfied his intellect. We first hear of him listening outside the door in which Ricci, the Court mathematician of Florence, who happened to be spending some time at Pisa with the Grand Duke, taught the pages a little Euclid. For a couple of months Galileo neglected his medicine, and greedily absorbed his Euclid through the key-hole till he found some chance opportunity of introducing himself to the Professor, who was delighted with his new pupil. Ricci presented him with a volume of Archimedes, and the great mathematician and physicist of Syracuse became the spiritual father of the young Italian student. In spite of the straitened circumstances of his family, and the chances of fortune that awaited him in a decorous prosecution of his regular medical studies, he deserted them, and attached himself to Ricci.

Watching one day the long swing of a lamp hung from the roof of a church, we are told that he noted the times it took in oscillation after oscillation, and found that though the arc through which it swept died down till it was scarcely visible, the time it took from each farthest right hand point to the succeeding farthest left hand point of its sweep was always the same. He applied the knowledge he had gained at once to the more accurate measurement of the regularity of the pulse beats. The observation of the student, and the immediate practical application of it, was the sure forerunner of the greatness of the man. He knew that Science is Measurement three centuries before Comte laid it down as the definition of mathematics, or Marks had been born to caricature the maxim in his diploma picture.

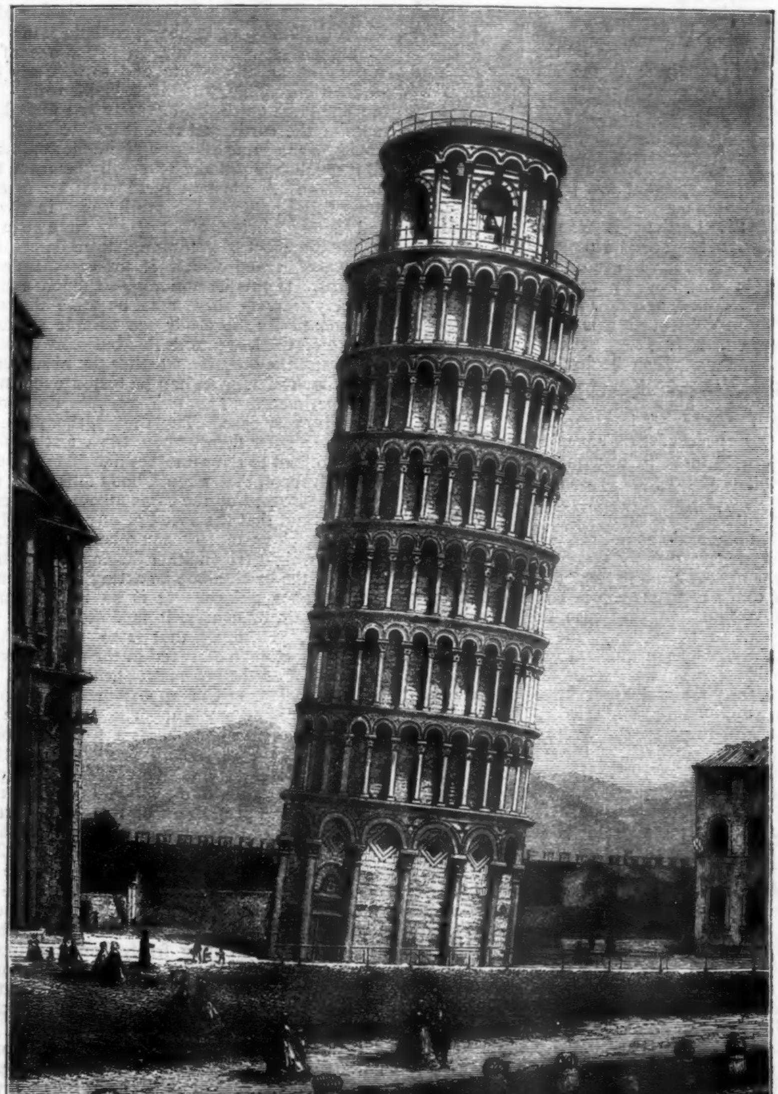
At that time the Peripatetic philosophy was dominant over Europe, and tyrannized in Italy. The followers of Aristotle naturally travestied the errors of their master. In his own time Aristotle was a genuine observer of nature, and, as Galileo afterwards said of him, he would have been the last to dispute a fact because it contradicted his preconceived opinions. His followers, who were not observers, had constituted a universe on high *a priori* principles. They taught that there were two great classes of things perishable and terrestrial, one heavy, tending by an irresistible law of their essential nature to the mathematical centre of the universe, the other light, and tending irresistibly away from it. Things imperishable and extra-terrestrial moved by a like necessity in everlasting circles round the centre of all things. A body of 2 lbs. weight, having more tendency to the centre than a body of 1 lb., must fall faster, and acquire a greater velocity in an equal time. With *a priori* principles like these observation was superfluous. Galileo questioned them and put them to the *examen rigorosum* of experiment. The explanation of the isochronism of the larger or smaller swings of the pendulum lay in the fact that though when the moving lamp started from a higher point it had further to fall—it began to fall more nearly perpendicularly and faster, and it swept through its larger arc with a greater velocity at every point. When he took two such pendulums of equal length, to the end of one of which a lamp weighing 1 lb. was fastened, and to the end of the other a weight of 2 lbs., Galileo found that their times of oscillation were the same.

The Peripatetic dictum of the greater gravity of heavier bodies was in contradiction with this simple fact. Galileo took the two weights to the top of the hanging tower of Pisa, and let them fall. They fell at the same or practically the same instant. Though the simultaneous thud of these two weights on the ground was the death-blow of the Peripatetic assumption, it was not enough to convince teachers who had grown grey in teaching it. But a moment's thought now will serve to show us not merely that it is so, but why it must be so. Instead of the mass of 2 lbs., imagine for a moment that the 2 lbs are made up of two single pound weights, each identical in shape and material with the other mass of 1 lb., and that all three drop together. All three will come to the ground together. If the two pound weights are made to adhere to each other by ever so thin a film of glycerine, there will be no strain on the film, and they will not separate. If an imaginary section is cut through a single mass of two pounds there will equally be no strain or shearing force along that section. The tendency of the two single lbs. downwards is twice as great as that of the 1 lb., but it has to move two masses instead of one. Ten runners who keep abreast of each other do ten times the work of an eleventh runner on the other side of the course. Man for man, each does the same work, and each man's work has the same effect in producing the racing speed of each. An imaginary or real thread might tie the ten together, but there would be no strain on the thread, which would not snap, if their rates of running were the same.

Galileo often returned to the pendulum, and completely

[1] An Introductory Lecture, by William Jack, M.A., LL.D., F.R.S.E., Professor of Mathematics in the University of Glasgow, formerly Fellow of St. Peter's College, Cambridge.

established the laws of its motion in ordinary small oscillations. He showed that though the weights at the end of the string have no effect on the times of oscillation the length of the string has, that these times are twice as long for a string four times as long, three times for one nine times as long, and always in the proportion of the square roots of the lengths. In proving this he had to investigate motion along a slope or Inclined Plane, and it was he who first showed that whatever the incline, the speed acquired by a body moving on it depends not on the amount of



The Leaning Tower of Pisa.

ground it has covered on the plane itself, but on the vertical drop between its starting point from rest, and its position at any moment. The pendulum moves along an arc of a circle, and something very like that arc would be got by drawing instead of it small chords of the circle from point to point in it successively. The smaller these successive chords become the nearer the sum total of them is to the arc, and the motion of a heavy particle constrained to move down them is substantially the same as that of the bob at the end of the pendulum. These suc-

cessive chords are so many inclined planes, and the movement of the weight down the entire series, is identical with the swing of the bob in the arc. More is necessary to establish this completely than Galileo was able to supply. In passing from plane to plane the particle must be supposed to make a slight rebound at each, a rebound which is less for each, according as the change of slope from one to the other becomes less and less, but the number of the planes, and therefore of the rebounds, increases in the same proportion as the slope of each to each diminishes. To reduce the swing of the bob in its arc to the fall of the mass down the planes it is necessary to show that the effect of this great number of small rebounds is negligible, and Galileo had not advanced far enough in the Fluxional Calculus to show it.

The principle that the speed at any point of the downward slope depends only on the vertical drop between the two positions of the particle, is true independent of friction which lowers the speed attained in a constant proportion. But it would have been difficult to establish the truth stated in this way by ordinary experiment. What is the speed attained, and how are we to recognise it? As the body goes downwards it is increasing in speed from moment to moment. It is easy to time a railway train running at a uniform rate. When the first quarter milestone he notices flies past him, a passenger sees, let us suppose, that the second hand of his watch is at 5 seconds, while at the next quarter milestone it is at 20, at the third 35, at the fourth 50. Every one of these equal intervals is swept over by the train in 15 seconds, or a quarter of a minute. The train is going at the regular rate of a quarter mile per quarter minute, or a mile a minute, or sixty miles an hour. Had the intervals of time noted been different, the problem would obviously have been much more complicated. Let us suppose that the two first 5 and 20, are as before, that the next is 40, and that at the fourth the second hand of the watch has again come round to 5 seconds past the minute. In that case the first quarter mile interval is done in 15 seconds, the next in 20, the third in 25. If the rates were uniform for each interval these figures would give us sixty miles an hour for the first quarter mile, forty-five miles per hour for the next, thirty-six miles an hour for the third. The train is slackening speed, and these are the average rates during the time spent in covering each of these quarter miles. But the train does not drop suddenly from one to the other, and nothing in nature does so. Point by point it has a different rate, and the question, What is the rate at any point? is not easily answered. How, then, are we to measure the rate of speed at a point when that rate is constantly changing? We must seek some necessary consequence of any law of change which we suppose, and we must transform the question, the answer of which it is difficult to verify, into one which it will be easy to subject to an experimental test. Galileo appealed to mathematics, and showed that if his theory, that the velocity depends on the vertical drop, be true, the amount of the vertical drop must be four times as great for two seconds, and nine times as great for three seconds, as for one second, and he set himself to compare the real with the theoretic result.

Let us consider what seems a simple thing, a fall in space, where there is no inclined plane at all. What is the amount of fall for so many seconds? The difficulty in answering accurately is that for even a short time the fall is very large. It is of no use distinguishing between a fall of 16 feet, for instance, and one of 20¼ feet, if the times of description, which are 1 second and 1⅛ second, are too nearly the same to be distinguished by our measurement of time. In Galileo's day the measurements of time were only beginning to be a little delicate, chiefly through his own discoveries, and an error of ⅛ of a second in measurement is obviously easy to make, when one of 4 feet is not easy. In the simpler case of free fall, therefore, Galileo could not compare spaces and times conveniently, because his measures of space were so much more accurate than those of time. The experimental test can be more readily applied to the inclined plane because the fall is slower and there is no other vital alteration in the conditions of the problem.

It is necessary to form some hypothesis about the law which the falling body obeys, to deduce the mathematical consequences of that law, to select one of them which admits of an immediate and satisfactory experimental verification. This was what Galileo did. He believed that the force on the falling body was probably due to the mass of the earth, and that it was at least likely that it would be the same all through the motion, as the particle all through it is practically equally far from the centre of that mass. A constant force must be measured by its constantly producing the same effect in the same time, and the first obvious effect of any force on a falling body is, like the effect of getting up steam on a locomotive, the change of speed which it produces from moment to moment. If this be uniform—so much extra speed put on every second—there must be some way of connecting mathematically the easily measurable spaces and times instead of the less practicable but more direct speeds and times, and the question whether the result and the theory at the back of it agree can be tested over and over again by experiment. The two answers do agree, and they agree in every case. The theory, therefore, is right, unless some other theory about the effect of forces can be found to lead to the same result. The hypothesis about the earth force, that when a body falls from rest its speed will be increased by the same amount in every equal time interval, and that the speed of any body will be increased just as much as that of any other, is a true hypothesis. A 10 lb. weight falls neither faster nor slower than a 1 lb. one. If the earth alone be acting on both, a feather falls as fast as a guinea. It is so in vacuum, though in ordinary air, of course, it is different. A force always the same, producing, that is to say, always the same amount of change of speed in the same time, is acting on every equal particle of matter at the earth's surface. To test this theory we can appeal practically to the inclined plane, rough or smooth. The force on a body falling along it at any moment bears a fixed proportion to that in a free fall; a very small proportion, if the plane has only a very slight slope. Obviously the length of the line along such a plane, down which a body runs in a second, is a very small proportion of that of the free fall in the same time. In the latter case, what to Galileo's power of measuring time was an almost imperceptible difference involved a very marked difference in the spaces gone through, so that it was difficult to verify the law. In the former the spaces needed to be measured for experiments lasting even a few seconds become reasonable. In three seconds a body falling freely from the top of a steeple 144 feet high would fall to the bottom, and it would only take five seconds to fall down Tennant's stalk, but it is easy to make a plane such that a body will only fall down 14 feet along it in three seconds.

It was in connection with his investigations of motion on a plane that Galileo laid down the principle that perhaps serves best as the basis of the theory of balancing forces, the principle of what is called Virtual Velocities. Every one is familiar with it, in the ordinary maxim, that what is gained in speed is lost in power. In the board laid across a fallen tree, on which children see-saw, the lighter child is put at the extremity of the longer arm. With a plank, 12 feet long, a child 50 lbs. weight will be balanced against one 70 lbs. weight when the plank rests on the tree 7 feet from the light child's end, and 5 feet from the heavy one's. When they swing, the amount of swing is proportional to the distances from the fixed point. If the plank moves, so that the child at the 7 feet end rises through seven inches, the other goes down

through five. In every case like this, where forces are in equilibrium on a system, we can imagine a motion given, every point moving according to the geometrical circumstances. Let us imagine such a motion. When two forces act on a system and keep it at rest, multiply the space through which the point of application of each force moves, referred to the line in which the force acts, by the measure of the force. When there is equilibrium the resulting quantities are equal and of opposite signs. The one child weighing 50 lbs. rises vertically through 7 inches, and we may call the product 350 inch-lbs. upwards. The 70 lbs. child moves in the same time 5 inches downwards, and the product, which is 350 inch-lbs. downwards, is equal and opposite to the other. If there is equilibrium it must always be so; if it is so there must be equilibrium. It was to Galileo that we owe this most fruitful of statical principles. It can easily be extended to the case when any number of forces act at any number of points on a body or a system, but it was not till a century later that John Bernouilli could state it in all its generality, or show how admirably it serves as a sufficient basis for the whole theory of equilibrium.

These laws of falling bodies and of virtual velocities marked the greatest advance in mechanical science since the world began. The nature of the earth's common action on all bodies at its surface had, in fact, been ascertained. The question that had been put directly to nature had been completely answered, and the answer was final.

The Peripatetics had a singular notion of what they called Inertia. According to them, a body had a natural tendency to move at a given speed straight towards the centre of the earth if it were heavy, and straight away from it if it were light. The continuance of that natural motion, in that direction, at that speed was ensured by inertia. Strike the body in that or in any other direction, and an immediate change takes place, but it is a change which disappears if the body is moving in a vacuum. In ordinary air it is kept up, because the air behind, from which the body is suddenly taken away when it is struck, instantly closes up, and strikes it like a spring which has been let go. At every new position it leaves air, and air springs after it to keep it going. As far as it was then possible, Galileo worked out the consequences of this theory and those of his own, which was that stated in Newton's first Law of Motion—that except where any external force operates, motion in any direction at a certain rate will continue indefinitely in that direction at the same rate. The result was that the old theory was proved to be wrong. As with the first law of motion, so with the second. It is substantially this, that when a force acts on a particle in motion, it produces the same effect in changing that motion as it would if, before it began to act, the body were at rest. Suppose a particle moving with a speed which may be described as 10 feet per second northward and 8 feet per second eastward. Let a force suddenly act on it, the effect of which is to change its rate of going to 17 feet per second northward and 13 feet per second eastward. The amount gained is an addition of speed of 7 feet per second northward and 3 feet per second eastward. Imagine the same force acting on a particle identical with the former, but initially at rest. It will make that particle begin to move from rest at the same rate of 7 feet per second northward and 3 feet per second eastward which it gained in the former motion. The effect in changing rate has been the same as if the body had been at rest, and the whole effect on the eastward direction has been the same as it would have been had there been nothing to affect it in a northerly direction.

It was through the combination of these two principles that Galileo was able to solve another and more difficult problem. Until they were verified by the success of millions of predictions founded on them, they were not so much principles as theories or hypotheses. A fulfilled prediction of any complicated phenomenon raises the hypothesis on which it has been explained to the dignity of a probable truth. Let a bullet be started in an oblique direction at a certain speed—we can predict, by applying these two principles, the way in which it will move and the course it will follow. Let us take one which is sent off at a rate of speed compounded of 32 feet per second vertical and 20 feet per second horizontal. At every point of its path, it will keep both these rates except so far as gravity changes them, and gravity will do by it as a moving body just what it would do by a body starting from rest. To the latter it would give a downward speed of 32 feet per second in a second. In a second it will give just enough downward speed, therefore, to annihilate the upward speed of the bullet. After a second, it will have ceased to have any upward speed, but it will go on with the horizontal speed of 20 feet per second. In its first second the bullet has moved away from its starting-point 20 feet in a horizontal direction and 16 feet upward, because a fall of 16 feet from rest is needed to generate that velocity of 32 feet per second downward, which is wanted to destroy the upward velocity of the amount with which it started. At the end of the first second it has reached its new position by a certain path. Till the bullet comes to the ground again another second will suffice, during which it will fall through 16 feet vertically, and acquire a speed of 32 feet per second downward as it started with 32 feet per second upward, and it will move horizontally 20 feet further from the starting-point. When the second second closes, the particle has again reached the ground by a path which is the left-handed facsimile of that by which it rose.

There are thus three measurable things, all consequences of our fundamental laws. Does the bullet rise 16 feet? does it strike the ground 40 feet away from where it started? does it take 2 seconds to do it in? Nature answers that all these things are so. If we take some means of making the bullet record or picture its path on a board or paper we shall have a still completer answer to the question. Galileo's mathematics were enough to show him that if these two laws were true the curve described must be a parabola—except so far as it is slightly modified by the resistance of the air—and the parabola calculated is the parabola described. Such a proof is all but conclusive. Every point in the path really found has thus been predicted as the mathematical consequence of these two laws, and when this prediction is repeated and confirmed in every experiment, doubt vanishes, the laws are securely established, and the secret of nature has been found.

(To be continued.)

JAMES CLERK MAXWELL, F.R.S.

JAMES CLERK MAXWELL, whose premature death on Wednesday last week, science has to deplore, was born in 1831, being the only son of John Clerk Maxwell, Esq., of Middlebie. His grandfather was Captain James Clerk of Penicuik, whose two sons were the Right Hon. Sir George Clerk, Bart., of Penicuik, and the above-mentioned, John Clerk Maxwell. Captain James Clerk was a younger brother of Sir John Clerk of Penicuik, and on the death of the latter Sir George Clerk succeeded to the estate of Penicuik, while John succeeded to the estate of Nether Corsock, part of the Middlebie estate, which had come into the family through marriage in a previous generation with Agnes Maxwell. Along with this estate John Clerk assumed the family name of Maxwell. When James Clerk Maxwell was eight years old, his mother died, and his father, who had been called to the Scotch Bar, but never practised as an advocate, lived a retired life, devoting himself to the care of his estates, and of his son.

James Clerk Maxwell was educated at the Edinburgh Academy, where he gained the Academical Club Medal for Geometry in 1845, and the Silver Medal for Mathematics in 1847. In 1848 his mother's brother, John Cay, of Edinburgh, took him to see William Nicol, who showed him the colours exhibited by polarised light after passing through unannealed glass, &c. This visit seems to have given the first impulse towards his researches in optics. On his return he constructed a polariscope with glass reflectors. The framework of the first was of cardboard, but a superior article was subsequently constructed by him in wood. Small lenses mounted in cardboard were employed when a conical pencil of light was required. By means of this instrument he examined the figures exhibited by pieces of unannealed glass which he prepared himself, and with a camera lucida, and a box of water colours, he reproduced these figures on paper, taking care to sketch no outlines, but to shade off each coloured band imperceptibly into the next. Some of these water-colour drawings he forwarded to Nicol, and was more than repaid by the receipt shortly afterwards of a pair of prisms prepared by Nicol himself. These prisms were always very highly prized by Prof. Maxwell. Once while at Trinity the little box containing them was carried off by his bed-maker during a vacation, and destined for destruction. The bed-maker died before term commenced, and it was only after a very diligent search that they were found among the late bed-maker's effects, which had been set aside as valueless. After this event the prisms were most carefully guarded, and about three weeks ago were deposited, at Professor Maxwell's request, in one of the show cases of the Cavendish laboratory. The study of the figures exhibited by unannealed glass in polarised light drew the attention of Clerk Maxwell more particularly to the equilibrium of elastic solids, a subject on which he has done some very valuable work.

After leaving the Edinburgh Academy James Clerk Maxwell entered the University of Edinburgh, where he soon won the esteem of Kelland, Forbes, and Gregory, under whom he studied and worked. In October, 1850, he came to Cambridge, entering at Peterhouse. At this time his father does not seem to have been very sanguine respecting the advantages to be derived from a Cambridge course, but his opinion of the University rose considerably when in 1854 the examiners showed their appreciation of his son by making him Second Wrangler, and bracketing him as first Smith's Prizeman. Clerk Maxwell's first term in Cambridge does not seem to have been a very happy one. The Peterhouse men were all classics or pure mathematicians, and he could get no sympathy in his physical work. Finding himself comparatively without friends at the end of the term, he consulted his father and his college tutor, and by their advice migrated to Trinity on December 14th, 1850, where, having a much larger number to select from, he not only found congenial spirits, but soon became looked up to as their leader by a set of admiring followers. In 1852, while an undergraduate at Trinity, he stayed for a few weeks at a country vicarage in Suffolk with the Rev. C. B. Taylor, a brother of a college friend. While there he was attacked by a serious illness, and the care and kindness with which he was nursed by Mr. and Mrs. Taylor never faded from his memory; it so impressed him with the power of love that it formed an important factor in the formation of the Christian character which all who knew regarded with an admiration akin to worship.

As above stated James Clerk Maxwell graduated as Second Wrangler and (bracketed) first Smith's Prizeman in 1854, having previously been elected a Foundation Scholar of his College. In 1855 he became a Fellow of Trinity, and in 1856 obtained the Professorship of Natural Philosophy in Marischal College, Aberdeen, which appointment he held till the fusion of Marischal College and King's College, when he, with other Professors, received a pension from the Crown. In 1858 he married Katherine, a daughter of Principal Dewar of Marischal College, thus vacating his fellowship at Trinity. In 1860 he succeeded Prof. Goodeve as Professor of Natural Philosophy and Astronomy in King's College, London, but after the death of his father he retired in 1865 to his estate in Scotland, where he subsequently carried out his father's plans for completing the house and offices at Glenlair. In 1871 he was invited by the Senate of the University of Cambridge to accept the Chair of Experimental Physics which had just been created, and on October 25th, 1871, he delivered his inaugural lecture as Professor of Experimental Physics in the University of Cambridge. At first the most important part of his work consisted in arranging the details of the Cavendish Laboratory which the Duke of Devonshire had offered to present to the University, and the building of which was personally superintended by Prof. Maxwell from first to last. The whole of the arrangements which render the Cavendish Laboratory so admirably adapted for Physical investigations, are due to the care and forethought of Prof. Clerk Maxwell. When the building had been completed and formally presented to the University, the Duke of Devonshire further signified his desire to provide it with a complete equipment of apparatus, and all this was procured under the personal supervision of the Professor. In 1872 he was elected Honorary Fellow of Trinity College, Cambridge.

During last winter Prof. Maxwell did not enjoy his usual health. In the spring he was unable to carry on his work with his accustomed vigour, but when he left Cambridge for Scotland his friends supposed that with mental rest and physical exercise his health would be restored, and did not regard his indisposition as other than temporary. In Scotland, however, his health did not improve, he suffered much pain and was unable to take his usual food. At length by the advice of his medical attendants, and of Prof. Saunders of Edinburgh, one of his former fellow-students, he returned to Cambridge in the beginning of October. Under Dr. Paget's care he at first made considerable improvement and some hopes were entertained of his recovery. He, however, gradually became weaker, and when Dr. Humphry visited him in conjunction with Dr. Paget, it was plain that medical skill could only alleviate his suffering. He died at noon on Wednesday, November 5th, having retained the conscious possession of all his mental powers to the last.

General invitations were sent to all members of the electoral roll of the University to assemble in Trinity College Chapel at 4·30 P.M. on Monday, November 10th, and were numerously accepted, especially by heads of houses (including the Vice-Chancellor), and by professors. About 4·45 P.M., the service was commenced by Mr. Stanford playing the "Dead March" upon the organ. The remains of the late Professor were then carried into the chapel, preceded by the choir and the first part of the Burial Service read. This was followed by the Anthem "If we believe that Jesus died and rose again, even so them also which sleep in Jesus shall God bring with him. . . . . Wherefore comfort one another with these words." After the service the assembly followed the body to the great gate, whence it was conveyed to Scotland to be interred in the family burying-place at Corsock, Kirkcudbright.

Prof. Maxwell was appointed Foreign Honorary Member of the American Academy of Arts and Sciences of Boston in November, 1874; Member of the American Philosophical Society of Philadelphia in October, 1875; Correspondent in the Mathematical Class to the Imperial Academy of Sciences, Göttingen, in December, 1875; Honorary Member of the New York Academy of Sciences in December, 1876; Associate of the Amsterdam Royal Academy of Sciences in April, 1877; and Corresponding Member of the Imperial Academy of Sciences, Vienna,

in August, 1877. He was Fellow of the Royal Societies of London and Edinburgh, and of the Cambridge Philosophical Society, and a large contributor to the Transactions of each of these. In 1872 he was created Honorary LL.D. of Edinburgh, and on June 21, 1876, he received the honorary degree of D.C.L. at Oxford.

In 1860 the Rumford Medal of the Royal Society was awarded to Prof. Clerk Maxwell "for his Researches on the Composition of Colours, and other Optical papers." In his address on the presentation of the medal, Major-General Sabine alluded to Prof. Maxwell's calculation showing the connection of the "mechanical strains to which elastic solids are subjected under certain conditions with the coloured curves which those solids exhibit in polarised light." He then alluded to the colour-top of Prof. Maxwell, and the colour-equations obtained from it, as well as the light it throws upon colour-blindness, concluding with these words:—"These researches for which the Rumford medal is awarded lead to the remarkable result that to a very near degree of approximation all the colours of the spectrum, and therefore all colours in nature, which are only the mixtures of these, can be perfectly imitated by mixtures of three actually attainable colours, which are the red, green, and blue, belonging respectively to three particular points of the spectrum."

While Professor of Physics at King's College, London, Maxwell was engaged as a member of the British Association Committee in the determination of the Absolute Unit of Electrical Resistance, and it was the comparison of electrical units which attracted a great part of his attention during his tenure of his Cambridge Professorship. He always spoke very highly of Faraday's "Experimental Researches," which he read very early in life, and to which he attributed some of his most useful ideas on electricity and electro-magnetism. In Clerk Maxwell Faraday found a mind constituted after the same plan as his own, but with the advantage of a mathematical training, which has made Prof. Maxwell capable of interpreting Faraday's bold realisations to the mathematical world. For Clerk Maxwell's own views of Faraday the reader may be referred to the article "Faraday," in the ninth edition of the "Encyclopædia Britannica."

It is impossible in a sketch like this to give anything but the most superficial view of a character so noble in all its aspects as that of Clerk Maxwell. As a professor he was wonderfully admired by those who were truly his disciples. He had not the power of making himself clearly understood by those who listened but casually to his pithy sentences, and consequently he was not a so-called popular lecturer; nor was he a most successful teacher of careless students. But when he had those about him who could enter into his mind, and, receiving the golden truths from his lips, could alloy them in such a way as to make them acceptable to the ordinary student, no better teacher could be desired, even for the most elementary instruction. His wonderful imagination was of great value, not only in supplying illustrations for didactic purposes, but in suggesting analogies and opening up new fields for research.

The pages of *Blackwood's Magazine* can testify to his talents as a poet; his sense of humour and his ready wit formed remarkable features in his character, in fact he seldom talked for many minutes without provoking at least a smile. (Some of the reviews lately contributed by him to NATURE may serve as illustrations.) He was well versed in all the literature of the day, and seemed to have investigated on his own account every system of philosophy. He took great interest in passing events, though he never indulged in political discussions. As an experimentalist he was too well known to require description; in that region of science which was his *par excellence*, viz., the domain of Molecular Physics, he stands without a rival. But there were other sides of his character which outshone even his scientific attainments. Such complete unselfishness and tender consideration as he exhibited for those around him, and especially for those under his control, are seldom to be met with. During the eight years that he held the chair of Physics in Cambridge, he never spoke a hasty word, even to his attendants. His self-sacrificing devotion to those he loved was the marvel of his friends. Though he never entered into theological controversy, and only occasionally in his scientific writings indicated in a sentence or two the side he took in questions which have recently been brought prominently before the public by some of the more popular men of science, those who had an opportunity of seeing into his home-life knew him to be an earnest Christian. About three weeks ago he remarked that he had examined every system of Atheism he could lay hands on, and had found, quite independently of any previous knowledge he had of the wants of men, that each system implied a God at the bottom to make it workable. He went on to say that he had been occupied in trying to gain truth, that it is but little of truth that man can acquire, but it is something to "know in whom we have believed." His simple Christian faith gave him a peace too deep to be ruffled by bodily pain or external circumstances, and left his mind free to the last to contemplate all kinds of questions of general interest. One day not long before his death he had been puzzling himself for some time in vain endeavours to discover why Lorenzo ("Merchant of Venice," Act v. scene 1), whose character was at least far from noble, says to Jessica—

"'Look how the floor of heaven
Is thick inlaid with patines of bright gold:
There's not the smallest orb which thou beholdst
But in his motion like an angel sings,
Still quiring to the young-eyed cherubins;
Such harmony is in immortal souls;
But whilst this muddy vesture of decay
Doth grossly close it in, we cannot hear it.'

We may quote one other example illustrating how the speculative character of his mind remained to the last. About five or six days before his death, when he was suffering from such extreme weakness that he could say very little, after lying motionless with his eyes closed for some time, he presently looked up and remarked, "'Every good gift and every perfect gift is from above, and cometh down from the Father of lights, with whom is no variableness, neither shadow of turning.' Do you know that is a hexameter?

'*πᾶσα δόσις ἀγαθὴ καὶ πᾶν δώρημα τέλειον,*'

I wonder who composed it."

His knowledge of hymns and hymn-writers was very extensive, and he took great pleasure during his illness in reciting from memory some of his favourites among the writings of Richard Baxter, George Herbert, and others.

To attempt to give any adequate idea of his contributions to science in a sketch like the present would be but to mislead the reader. His great work on "Electricity and Magnetism," the second edition of which is now in the press, is the admiration of mathematical physicists. More generally known are his treatise on the Theory of Heat, and his little text-book entitled "Matter and Motion" which was published by the S.P.C.K. One of his earliest papers on the "Theory of Rolling Curves," was communicated to the Royal Society of Edinburgh by Professor Kelland, and read on February 19, 1849, when Clerk Maxwell was an Edinburgh student barely eighteen years of age. His paper on the "Equilibrium of Elastic Solids," above alluded to, was read before the same society on February 18, 1850. His paper on the "Transformation of Surfaces by Bending" was read before the Cambridge Philosophical Society on March 13, 1854, about two months after taking his degree. This

was followed in December, 1855, and February, 1856, by papers on "Faraday's Lines of Force." In 1857 he obtained the Adams Prize, in the University of Cambridge, for his paper on the "Motions of Saturnian Rings." His paper on the "Theory of Compound Colours, and the Relations of the Colours of the Spectrum," which was chiefly instrumental in gaining the Rumford Medal, was read before the Royal Society on March 22, 1860. His "Dynamical Theory of the Electromagnetic Field," including a brief sketch of the Electromagnetic Theory of Light, was read before the Royal Society on December 8, 1864. The results of Clerk Maxwell's experiments on "The Viscosity and Internal Friction of Air and other Gases," were made known to the Royal Society in the Bakerian Lecture read, February 8, 1866. Then follow his Royal Society papers "On the Dynamical Theory of Gases," in May, 1866, and "On a Method of Making a direct Comparison of Electrostatic with Electromagnetic Force, with a Note on the Electromagnetic Theory of Light," in June, 1868. Lately he took great interest in Graphical Statics, and contributed a long paper "On Reciprocal Figures, Frames and Diagrams of Forces," to the Royal Society of Edinburgh, in December, 1869. Among his most recent papers are a paper on "Stresses in Rarefied Gases arising from Inequalities of Temperature," read before the Royal Society on April 11, 1878, and a paper on "Boltzmann's Theorem," read before the Cambridge Philosophical Society. It would take too long to enumerate his articles and reviews published in the *Philosophical Magazine* and in NATURE. His contributions to the ninth edition of the "Encyclopædia Britannica" include the articles "Atom," "Attraction," "Capillary Action," "Constitution of Bodies," "Diagrams," "Diffusion," "Ether," "Faraday," and "Harmonic Analysis." "Harmonic Analysis" was the last article he wrote.

One of the most remarkable of his works is the recently-published volume of the Electrical Researches of the Hon. Henry Cavendish, of which Prof. Maxwell is the editor. The MSS. are in the possession of the Duke of Devonshire, and are now at Chatsworth. They were entrusted by him to Prof. Maxwell shortly after the completion of the Cavendish Laboratory. Some of Cavendish's experiments were repeated by Prof. Maxwell with all the appliances of modern apparatus, and others were carried out by his pupils.

Most of the apparatus which he employed in his researches has been presented by Prof. Clerk Maxwell to the Cavendish Laboratory, together with many of his books. He always regarded the laboratory with great affection, and the University owes much to his liberality. One of the most interesting pieces of his handy-work now preserved in the laboratory is a plaster model of Prof. Willard Gibbs's thermodynamic surface, described in the fourth edition of "Maxwell's Theory of Heat." All the lines on the surface are drawn by his own hand, many of them being mapped out by placing the surface obliquely in the sunshine and marking the boundary between light and shade. Another valuable model constructed while Prof. Maxwell was at Cambridge is his dynamical illustration of the action of an induction coil in which two wheels represent by their rotation the primary and secondary currents respectively, the wheels being connected through a differential gearing to which a body of great moment of inertia is attached, the rotation of which represents the magnetism of the coil. A friction break represents resistance, and a spring may be attached to the secondary wheel to represent the capacity of a condenser placed in the secondary circuit. Among other valuable pieces of apparatus presented by Prof. Maxwell to the laboratory are the receiver, plates, and inertia bar employed in his researches on the viscosity of air and other gases, his colour-top, portions of the "colour-box," including the variable slits, with the wedge or measuring their width, a polariser and analyser made of thin films of stretched gutta percha, the mechanism for illustrating the motion of Saturnian rings, a real image stereoscope, and the dynamical top, whose moments of inertia about three axes, which are at right angles to each other, can be so varied by means of screws that the axis of rotation can be made that of greatest or of least moment of inertia. When the axis of rotation is the mean axis, the motion of the top is, of course, unstable. When Prof. Maxwell came to Cambridge in 1857 to take his M.A. degree, he brought this top with him from Aberdeen. In the evening he showed it to a party of friends in college, who left the top spinning in his room. Next morning he espied one of these friends coming across the court, so jumping out of bed, he started the top anew, and retired between the sheets. The reader can well supply the rest of the story for himself. It is only necessary to add that the plot was completely successful.

Prof. Clerk Maxwell's papers will be placed in the hands of Prof. Stokes, who is one of his executors, in order that they may be published or catalogued and preserved in such a way as to be readily available to those wishing to consult them.

The death of James Clerk Maxwell is a loss to his University and to the world too great for words. He rests from his labours, but his works will follow him.

WM. GARNETT

NOTES

THE following is the list of officers to be proposed at the anniversary meeting of the Royal Society on December 1:—President—William Spottiswoode, M.A., D.C.L., LL.D Treasurer—John Evans, D.C.L., LL.D., V.P.S.A. Secretaries—Prof. George Gabriel Stokes, M.A., D.C.L., LL.D., Prof. Thomas Henry Huxley, LL.D. Foreign Secretary—Prof. Alexander William Williamson, Ph.D. Other Members of the Council—George Busk, V.P.L.S., Prof. Arthur Cayley, LL.D., Major-General Henry Clerk, R.A., Edwin Dunkin, F.R.A.S., Augustus G. Vernon Harcourt, F.C.S., Sir Joseph Dalton Hooker, C.B., K.C.S.I., D.C.L., John Whitaker Hulke, F.R.C.S., Lieut.-General Sir Henry Lefroy, C.B., William Newmarch, Inst. Fr. Corr., Prof. Alfred Newton, M.A., V.P.Z.S., Prof. William Odling, M.B., V.P.C.S., Sir James Paget, Bart., D.C.L., William Henry Perkin, Sec. C.S., Charles William Siemens, D.C.L., John Simon, C.B., D.C.L., Prof. John Tyndall, D.C.L., LL.D.

A MEMORIAL strongly recommending Lord Rayleigh's election (if he can be induced to become a candidate), to the Professorship of Experimental Physics at Cambridge, is in circulation. Lord Rayleigh's merits for such an appointment are perfectly well known to our readers. We understand that his election will be supported by many of the professoriate.

WE are pleased to hear that Prof. Sir Wyville Thomson is now much better, and able to conduct the correspondence in connection with the *Challenger* work.

THE death is announced, at Florence, of Miss Martha Charters Somerville, the only surviving daughter of Mrs. Mary Somerville, in her sixty-sixth year. Miss Somerville enjoyed a pension of 100*l*. a year, in recognition of the services rendered to science by her mother.

THE Royal Institution Christmas Lectures will be given by Prof. Tyndall. The subjects will be Water and Air.

ON Tuesday night Dr. W. W. Hunter, the Indian Director-General of Statistics, delivered a lecture at the Philosophical Institution of Edinburgh, on the subject of "What the English had done for India." Contrasting the present English condition of the country with what it has become, since we have had to do with it, Dr. Hunter showed that the improvements in the land, and in the lot of the people had been immense. We need

not refer here to the purely governmental improvements which have been made, by the substitution of a good government for a bad, or for no government at all. The peace and security which the poorest native now enjoys was unknown before. Much of the improvement which has taken place has been due to the introduction of science and its results into India. As the *Times* puts it in a leader on Dr. Hunter's address:—"A country which, in the natural course of things, seemed fated to be long shut out from the light of civilisation, or to receive tardily a few rays, was admitted at once into the full blaze of noonday. Other nations have been doomed to work out their civilisation with painful striving. But, thanks to her association with the West, India has had no such novitiate to undergo. All that Europe could teach or give has been made free to her without trouble or price. She has had no centuries of painful waiting, but has stepped at once into possession of all the accumulated intellectual wealth of the West. This has already borne fruits, and more must follow. Our Indian fellow-subjects are being rapidly familiarised with our language and books, and they eagerly drink in modern ideas. They study our philosophers, and talk with more or less intelligence of Mr. Darwin or Mr Herbert Spencer. The names of our chief scientific men are as well known at Agra or Poona as in London. Our schools and colleges are the little leaven which will not fail to leaven the whole mass. The old intellectual idols and prejudices are already prostrate or tottering; and even were there no traces of a bridge or a road to tell of our sway, its history would be imperishably written in the intellectual revolution which we have swiftly effected."

DURING the last four years, *Science News* states, very little has been heard of the observatory to be built in California from the gift of Mr. James Lick, and the public has very generally supposed that nothing would come of the project. But there are now signs of a renewed activity on the part of the trustees, and evidence of an intention to carry the project through without further delay. In August last, Mr. S. W. Burnham, of Chicago, the well-known observer of double stars, was invited to spend a month or two on Mount Hamilton, with his telescope, in order to test the suitability of the mountain as a site for the proposed observatory. His reports were so favourable that Prof. Newcomb, on whose recommendation he was chosen for the work, visited the place himself in September. Both these gentlemen speak in the highest terms of the excellence of the astronomical conditions. Not only is almost every night perfectly clear, but, according to Mr. Burnham, bad seeing is almost unknown. Every night is such a one as he would consider superb at Chicago, and would only meet with two or three times a year. He discovered during his stay a number of new double stars, in portions of the sky which are further south than can be thoroughly examined in the comparatively bad atmosphere of stations this side of the Mississippi. The result of this exploration will give both the trustees and the public a new interest in the project, and it is supposed will lead the former to push the work on as rapidly as possible. If, as both the astronomers who have examined the site seem to suppose, its atmosphere is finer than that of any existing observatory, the result will be that the most powerful telescope in the world will be under the finest sky for employing its utmost capacity.

M. FEIL, the Paris glass-founder, has just received an unusual number of orders for large discs for the following observatories:—Pulkowa Observatory, 80 cm. diameter; Nice Observatory (Bischofsheim's gift), 76 cm.; Paris National Observatory, 73 cm.; Vienna Observatory, to be worked by Grubb, 70 cm.; Mr. Hilger for England, 52 cm.; and M. Salmocroghi, of Milan, 52 cm. The Nice Observatory object-glass will be worked by MM. Henry Brothers.

ON Thursday, November 4, took place at the French Ministry of Public Instruction, the first general meeting of the delegates of the Meteorological Commission. M. Jules Ferry was in the chair, and he prefaced the discussion by some remarks on the zeal exhibited by delegates and expressed the confidence felt by the Government in the ultimate success of so many efforts. M. Hervé Mangon, the president of the Council of the Central Bureau, read a report on the work accomplished since the institution was created, and directed attention to a number of useful questions which up to that moment had been too much neglected. All the resolutions proposed which had been discussed in preliminary meetings were accepted. A number of delegates delivered addresses asking for the erection of new stations and the improvement of certain departments.

THE French Minister of Public Instruction has appointed a commission for arranging all the collections now located in the Trocadero, and creating out of these valuable elements an ethnographical museum.

UNDER date Rome, Sunday night, the *Daily News* correspondent telegraphs:—"Galvani in the act of touching with two different metals the lumbar nerves of a vivisected frog; such is the monument, admirably executed in marble, which his native city, Bologna, has this day dedicated in her busiest street to the great discoverer of animal electricity."

IT is stated that the Bell Telephone Company have taken the first steps to bring an action against the Edison Telephone Company for infringement of patent in respect of the microphonic transmitter of hard carbon employed in the latest form of instrument. This transmitter, which is almost identical with the Blake microphone used by the Bell Company, is claimed by Edison, under the name of the *Inertia Telephone*, as one of the earliest forms of his carbon telephone.

THE programme of the Society of Arts for its 126th session has just been issued. It gives a list of the papers and lectures for the session, so far as they have been arranged. The following are the papers to be read at the evening meetings previous to Christmas:—November 26, "Suggestions for Dealing with the Sewage of London," by Major-General H. Y. D. Scott, C.B. F.R.S. December 3, "Apprenticeship: Scientific and Unscientific," by Silvanus P. Thompson, D.Sc., Professor of Applied Physics at University College, Bristol. December 10, "Art Vestiges in Afghanistan; the Results of some Recent Explorations in the Jellalabad Valley," by William Simpson. December 17, "The Panama Canal," by Capt. Bedford Pim, R.N., M.P. The dates of the papers after Christmas are not announced, but the following are among the subjects to be treated:—"Domestic Poisons," by Henry Carr; "Gas Furnaces and Kilns for Burning Pottery," by Herbert Guthrie, C.E.; "The Utilisation of Slag," by Charles Wood; "Art in Japan," by C. Pfoundes; "The Trade and Commerce of the Yenisei," by Henry Seebohm; "Modern Autographic Printing Processes," by Thomas Bolas, F.C.S.; "The History of the Art of Bookbinding," by Henry B. Wheatley, F.S.A.; "Art Ironwork," by J. W. Singer; "The History of Musical Pitch," by A. J. Ellis, F.R.S.; "The Recent History of Explosive Agents," by Prof. Abel, C.B., F.R.S.; "Ireland and its Resources," by C. G. W. Lock: "The Future of Epping Forest," by William Paul, F.L.S. Three courses of "Cantor Lectures" are to be given. The first course is by Dr. Charles Graham, F.C.S., F.I.C., Professor of Chemical Technology at University College, London, on "The Chemistry of Bread and Bread-making;" the second on the "Manufacture of India-rubber and Gutta-percha," by Thomas Bolas, F.C.S.; the third by R. W. Edis, F.S.A., on "Art Decoration and Furniture." The first meeting of the session will be held on the 19th inst., when the opening address

will be delivered by Lord Alfred S. Churchill, chairman of the Council.

DR. HINCKS's "History of the British Marine Polyzoa," upon which he has long been engaged, is nearly ready for publication; it will form two volumes, uniform with the same author's "Hydroid Zoophytes," and will be fully illustrated by drawings of all the known British species and more remarkable varieties of this hitherto almost undescribed class. The work will be published by Mr. Van Voorst.

MESSRS. BUNNY AND DAVIES, of Shrewsbury, have published a "Guide to the Botany, Ornithology, and Geology of Shrewsbury and its Vicinity," edited by Mr. W. Philips, F.L.S.

THE freedom of the Leathersellers' Company has been conferred on Prof. Owen.

ON November 3, at 7.45 P.M., a magnificent meteor was observed at Strassburg, in the vicinity of Jupiter, travelling south-eastwards. The duration was four to five seconds. The meteor was coloured green, and left behind a luminous track.

IN his just published report on the trade of Newchwang, in Southern Manchuria, Mr. Consul Adkins mentions that he has in his possession a specimen of lead ore found in the neighbourhood, which contains about 90 per cent. of metal, and also one of copper from the same locality which is almost equally rich. An attempt is being made to get authority to work these mines with foreign appliances. There is an abundant supply of excellent coal close to the veins of metal, and were the mining industry once fairly started, the prosperity of Newchwang and the whole province would, in Mr. Adkins's opinion, become remarkable.

THE additions to the Zoological Society's Gardens during the past week include a Rhesus Monkey (*Macacus erythræus*) from India, presented by Mr. Thos. G. Anderson; a Common Barn Owl (*Strix flammea*), British, presented by Mr. F. Bagnall; a Vervet Monkey (*Cercopithecus lalandii*) from South Africa, a Mona Monkey (*Cercopithecus mona*) from West Africa, a Malbrouck Monkey (*Cercopithecus cynosurus*) from East Africa, deposited; two Moustache Monkeys (*Cercopithecus cephus*) from West Africa, an Axis Deer (*Cervus axis*) from India, a Quebec Marmot (*Arctomys monax*) from North America, a Common Weasel (*Mustela vulgaris*), British, two Boatbills (*Cancroma cochlearia*), two Variegated Bitterns (*Ardetta involucris*) from South America, a Common Night Heron (*Nycticorax griseus*), British, purchased.

METEOROLOGICAL NOTES

IN the *Meteorology of England* for the quarter ending June 30, Mr. Glaisher gives some interesting notes of the cold weather up to that date. The mean temperature of London for the quarter was 49°·5, being the lowest which has occurred during the corresponding period since 1837. The unusually protracted cold weather set in on October 27, 1878, and for the eight months ending June, 1879, the mean temperature was only 41°·6, being lower than any which has occurred in the present century since 1813-14, when the mean temperature of these eight months was only 40°·4. It was during this cold period that the Thames was frozen over and a fair held between London and Blackfriars Bridges. Mr. Glaisher appends a very valuable table showing the mean temperature of the eight months ending June for each year from 1771-72, from which it appears that five colder periods than that of the present year occurred towards the end of last century, viz., 40°·9, in 1794-95, 41°·2 in 1788-89, and 41°·3 in 1783-84, 1784-85, and again in 1796-97. The more frequent occurrence of a higher temperature during the colder half of the year in recent years as compared with what prevailed in the end of last century is pointed out. During the first six months of 1879 the rainfall about London has been exceptionally large, amounting to 17·30 inches, which is larger than has fallen in these months any year since 1815.

IN the *Transactions and Proceedings* of the Philosophical Society of Adelaide, South Australia, for 1877-78, there is an interesting paper by Mr. H. H. Hayter, Government Statist of Victoria, on the infantile mortality of our Australian colonies, based on the statistical returns from 1866 to 1877. During these twelve years the rates per annum of the mortality of infants under one year of age in proportion to 1,000 births were 155 in South Australia, 128 in Queensland, 125 in Victoria, 106 in New South Wales, 101 in New Zealand, and 100 in Tasmania. In each of the years South Australia stood at the top of the list, except in 1877, when the rate of its infantile mortality was slightly exceeded by that of Queensland. From a detailed statement of the causes of deaths of infants in South Australia for the three years 1873-74-75, it appears that of the 3,641 deaths which occurred during these years from all causes, no fewer than 2,249 were occasioned by bowel-complaints and their complications. The whole of this question, which is a vital one as affects the future of such of our colonies as are characterised by high summer temperature, can only be satisfactorily investigated by weekly or monthly statistics of deaths of infants from all causes taken in connection with the mean temperature and humidity of the air during the time. Thus the different summer temperatures and humidities of these colonies explain by far the larger proportion of the differences in the rates of their infantile mortality. All the differences, however, are not to be thus explained, and it is the investigation of these and the tracing of them to their causes which would likely lead to the adoption of improved sanitary and domestic arrangements.

WE have received from the Scottish Meteorological Society a communication from Mr. Thorlacius, their observer in the north-west of Iceland, in which he states that the spring there was stormy and cold, but that, in direct contrast to what has prevailed in the British Islands, the summer had been very fine and warm up to the date of writing (September 23), and the rainfall very small during June, July, and August. Pastures had, in consequence, suffered much, and the hay crop turned out to be generally a very poor one. This has, however, been to some extent counterbalanced by the admirable state in which the hay harvest has been secured, so that most can look forward to the coming winter without uneasiness, even though it should prove severe. Since April they have heard nothing of the Greenland ice, always a subject of no little anxiety in these parts, the ice having fortunately kept away from the coast of Iceland. The Danish man-of-war schooner *Ingolf*, Capt. Mourier, cruised this summer close to the coasts of Greenland, but could effect no landing, owing to a belt of ice he could not force his way through, which lay along the shore for a distance of from twelve to sixteen miles. The Captain sailed along the coast, taking several bearings by the way, from Stewart's Island to Cape Dow, or from 69° to 65° 30' lat. N., thus sailing in a south-westerly direction along the coast of Greenland, which lies opposite the north-west of Iceland, at a distance of about 120 nautical miles. This shore has not been previously explored, no one having probably ever had an opportunity of getting so close in shore before. The strait between Iceland and Greenland was this summer, which very rarely happens, quite open for navigation, except the inconsiderable belt of ice immediately outside the coast of Greenland. Capt. Mourier had special instructions from the Danish government in regard to this exploration, and it is considered likely that the explorations on this little-known coast will be resumed. These meteorological and geographical facts are important in relation to the more southerly course than usual recently taken by our European storms, and the easterly and northerly winds resulting therefrom, to which we owe the all but unexampled cold dull weather of the past twelve months.

THE "Results of Observations in Meteorology, Terrestrial Magnetism, &c., made in Victoria during 1876," under the superintendence of R. L. J. Ellery, have been received. The methods of making and reducing the observations are detailed at length in the preface. The chief feature of the Report is its purely statistical character, there being no attempt to state the outstanding points of interest in the meteorology of the year in this part of Australia. To some extent, however, this want is compensated for by there being given with each month's detailed results the averages for that month of pressure, temperature, humidity, and rainfall, calculated from all previous observations in the office—together with particularly full data of electrical phenomena, hail, snow, frost, fogs, hot winds, storms of winds, and heavy rainfalls of half an inch and upwards within the twenty-four hours at the thirty-eight rain stations over the colony.

These hot winds are not merely of local interest to the colonists, but of general interest in matters affecting the atmospheric circulation of the continent of Australia, and as affording facilities to the meteorologists of that region in the study of whirlwinds and other cyclonic movements, the correct theory of which science has still to propound. The frequency of these hot winds at Wilson's Promontory, the most southern point in Victoria and completely enveloped by the sea, is noteworthy, as also the instance which occurred on March 14, when on the surface the wind was cool and damp, whereas a hot wind was blowing 50 feet high on the lighthouse balcony. The discussion of the wind observations is a valuable piece of work. These show an excess of atmospheric movement in the warmer months and during the hottest hours of the day, the velocity of the wind in summer increasing from 7·13 miles an hour from 2 to 3 A.M. to 15·97 miles from 2 to 3 P.M. During 1876, which was remarkable for the absence of sun-spots, the aurora australis was only seen once, viz., between 3 and 4 A.M. of April 26 at Kyneton.

GEOGRAPHICAL NOTES

THE Germans have so deservedly earned a distinguished reputation as scientific geographers, that it is quite pleasing to catch one very seriously tripping in geographical matters. In Philip Leopold Martius's "Das Leben der Hauskatze und ihrer Verwandten" (Weimar: B. F. Voigt, 1877), in the part of the work treating of the varieties of the domestic cat, appears (s. 61) the following extraordinary statement: "Die schwanzlose Katze von der Insel Man *im stillen Ocean* wenn nicht das *Kap Man auf Borneo* darunter zu verstehen, ist wohl noch nie zu uns nach Deutschland gekommen, obgleich sie auf der Katzenausstellung in London einst vertreten war." The author goes on to express his earnest wish that a pair of these great rarities, Manx cats, may be procured and exhibited at some zoological garden. Manxmen will hardly thank him for placing their native isle in the Pacific Ocean and confounding them with Polynesians, but the suggestion as the result of ponderous research that after all perhaps such a place as the Isle of Man does not exist, but that its mythical development has arisen from a mistake as to a cape of the same name in Borneo is too delicious altogether, and so ingenious and thoroughly German that it must needs be recorded for the benefit of the readers of NATURE.

DR. NACHTIGAL, has communicated to the Berlin Geographical Society full particulars as to the misfortune lately suffered by Gerhard Rohlfs' expedition in North Africa. Rohlfs and his companions, who were plundered and detained while exploring the Kufara Oasis, and compelled to return to Bengazi, were relieved by the intervention of the Foreign Office under assurance that complete reparation would be made them. The explorers' travelling effects, along with gifts sent by the German Emperor for the Sultan of Wadai, require to be supplemented and renewed, though it is almost certain the expedition will still be able to proceed in accordance with its previous plan. Dr. Lenz, it was announced at the same meeting, had lately gone to Morocco on a geological survey, which he would subsequently extend eastwards into the Sahara.

AT the opening of the Geographical Society's Session on Monday last, the Earl of Northbrook, the president, briefly reviewed the work of travellers and geographers during the past few months, and spoke in very eulogistic terms of Prof. Nordenskjöld's great achievement. The most noteworthy feature, however, in the address, was the statement that news had been received that morning from the expedition despatched by the African Exploration Fund Committee to the head of Lake Nyassa. Nothing had been heard of its whereabouts since the death of Mr. Johnston, except a rumour as to its progress, gathered by an Arab from native sources, and lately communicated by Dr. Kirk through the Foreign Office. Mr. Thomson reports that he has arrived, within comparatively few days' march of the lake, in the country of Uhéhé. Lord Northbrook read some interesting extracts from Mr. Thomson's journal which will, no doubt, soon be published by the Society. Mr. Clements R. Markham then read a summary which he had drawn up of a paper on the exploration of Central Sumatra, prepared by Prof. P. J. Veth, President of the Dutch Geographical Society. One of the main results of the late Dutch expedition, was the discovery that the Jambi River, which should be known by its native name of Batang Hari, was navigable for nearly 400 miles. It was announced that at the next meeting a paper would be read which had been written by Captain A. H. Markham, descriptive of his Arctic cruise during the summer in the *Isbjörn* and of the work of the Dutch Expedition in the *Willem Barents*. Captain Bruijne, its commander, has kindly promised to attend the meeting. Lord Northbrook also stated that hopes were entertained of Dr. Emil Holub being able to give an account of his remarkable journeys in South Central Africa on January 12.

IN an account which he has sent home to the Church Missionary Society, of the tribes on the road to Mpwapwa, Mr. J. E. Last tells us that the third tribe from the coast is that of the Wanguru. In going from Saadani to Mpwapwa caravans pass through the southern limits of their country. These Wanguru seem to be a scattered people, but they are found in great numbers living among the mountains north of Kwa Masengo, one of their chief villages. There they cultivate the ground on a large scale, growing rice plentifully and all the common native produce; ginger is found in great abundance. They also grow a great deal of tobacco, and three native medicines not known among other tribes. One is the seed-pod of the *mdaka*, in form very like a piece of rough stick, and when ground it is very hot to the palate. The other two are vegetable fats produced from seeds, and are much in vogue as medicines at Zanzibar, as well as on the coast and inland. The French Roman Catholic mission have had a station among this tribe for some little time.

NEWS has been received from Zanzibar that another expedition has started from Bagamoyo for the interior. It is despatched by M. Lavigerie, Archbishop of Algiers, and consists of eighteen Europeans, of whom six are laymen. Their object is to reinforce the Algerian missionary stations at Ujiji and at King Mtesa's capital. The expedition is under the leadership of the Abbé Guyon.

THE new number of *Les Annales de l'Extrême Orient* contains papers on the Belep group and the fauna of the Indian Archipelago, the former of which is illustrated by a map.

THE fame of the newly discovered sapphire mines in Siam is so great that great numbers of Burmese and Shans are said to be flocking thither. The mania appears also to have attacked part of the European community in Rangoon.

THE November number of *Petermann's Mittheilungen* contains a reduced copy of the geological map of India from Medlicott and Blanford's "Preliminary Sketch." The narrative of Dr. Regel's journeys in Central Asia is concluded, and is followed by an interesting account of the trade and industry of Werchojansk and Kolymsk circles, in North-East Siberia, and an eclectic article on the region about the sources of the Santa-Cruz, in Patagonia, with a map illustrating Moreno's journeys in 1876-7. There is also a map accompanying the paper on Dr. Regel's journeys.

AMONG the papers in the September number of the *Bulletin* of the Paris Geographical Society, the one of most scientific value is Commander Perrier's lecture on the measurement of longitudes in France. M. Ed. Cineré describes his journey in South America, mainly the United States of Columbia, in 1875-6. There are two interesting letters on the Oxus question, by M. Woeikoff, with a note by M. Vivien de St. Martin, and a paper by the Abbé Durand on Père Dupayrett's journeys in South Africa. There is also an interesting unpublished letter of Dagelet, the astronomer attached to the expedition of La Perouse.

THE general council of Constantine (Algeria) has appointed a commission for determining the *tracé* of the Transaharian railway. It has been already determined by the commission to publish a *projet*, by M. Peltreau, on the section from Constantine to Juggurt by Biskra and Oued Birh.

IN the last session of the Geographical Society of Paris a very interesting discussion took place on the possibility of using elephants from India in South African exploration. It was considered more advantageous to try to use the native elephants after being trained on the Indian method. It was stated that a number of African elephants had been also sent to India in order to be tamed there. M. Soleillet remarked that elephants can nowhere be met in India except in well-watered places, so that they must be used in Africa, in countries offering some analogy with such regions where they can live without difficulty.

M. PAUL SOLEILLET will leave very shortly for St. Louis (Senegal) in order to proceed on his intended journey to Segou-Sokkoro and thence to Timbuctoo. He has received funds from

M. Ferry, the Minister for Public Instruction, enabling him to take with him a trained botanist. In his last address before the Geographical Society of Paris he entered into many interesting details showing that the negro populations of the region he is to visit were half-civilised races susceptible of intercourse with European nations.

THE public subscription for M. Miclucho-Maclay gives very good results. On November 1 the sum had already reached, at the *Golos* office alone, above 2,786 roubles (about 278*l*.)

UNIVERSITY AND EDUCATIONAL INTELLIGENCE

CAMBRIDGE.—The anniversary dinner of the Cambridge Philosophical Society is to take place in the new hall of Pembroke College on November 29, at 7.15, under Prof. Newton's presidency. The occasion will be clouded by many memories of Professors Maxwell and Garrod.

The Botanic Gardens Syndicate are to obtain plans and estimates for the erection of a curator's house in the Garden.

There is much questioning as to Dr. Power's justification for regarding the coming changes as a "revolution," especially in laying down the office of Vice-Chancellor. A reform in which the University concurs to a great extent can hardly be regarded with such grave anxiety. Dr. Power, in the speech referred to, said that the new comparative anatomy buildings had been for a considerable period in use, although the dispute as to the respective liabilities of the University, the architect, and the contractors for the accident to the roof and floors is not yet settled. The recent addition to the rooms for human anatomy had proved satisfactory. Dr. Power again warned the University of the rapid rate of increase of permanent expenditure and the very uncertain nature of the income, depending so largely on the fees and dues from members of the University. He acknowledged that the department of chemistry had been existing on a starvation allowance, and that some professors and lecturers had been paying heavy expenses out of their own pockets rather than make fresh demands on the already overburdened finances of the University.

Dr. E. H. Perowne enjoys the singular felicity of having become Master of Corpus Christi and Vice-Chancellor in one year. Mr. G. F. Browne, the senior proctor, desires to maintain strongly the college system as against the lodging-house system, especially in regard to discipline. But this would not involve any diminution in the urgent need for more thorough University science-teaching, and the more complete recognition as a duty, of banishing the mere schoolboy and the idler, or the mere athlete, to the schools or elsewhere, instead of employing such ability as is here set to lecture in the ABC of subjects.

At Christ's College it is proposed to give open scholarships and exhibitions in natural science for entrance in October, 1880, by examination on Friday, March 19, and following days. He must show that he will probably be able to pass the "Little-go" at latest by the end of his third term of residence. A candidate may gain a scholarship for mathematics or classics in combination with natural science. No candidate will be admitted who has kept any actual terms by residence, but there will be no limitation of age. In mathematics there will be papers in Euclid, algebra, plane trigonometry, and conic sections, geometrical and analytical. Candidates for natural science scholarships must all take chemistry, and also either physics or biology in addition. The principles of spectrum analysis are included in theoretical chemistry, physical measurements and manipulations in physics; also statics, dynamics, optics, heat, and electricity; in biology the conditions are exceedingly well stated, as—*Physiology*: Fundamental principles of the chief physiological processes of plants and animals; general histology of their principal organs; *Morphology*: Fundamental principles of morphology as illustrated by forms representing the principal classes of the vegetable and animal kingdoms; principles of the classification of plants and animals; practical microscopical examination of the various tissues; dissection and description of typical plants and animals. The examinations will be held in common with those at Emmanuel and Sidney Sussex Colleges, as before.

The last Report of the Board of Natural Sciences Studies was to be offered for confirmation to-day (Thursday), at 2 P.M., and it was expected to be non-placeted, although it might be carried on a division.

PROF. BURDON-SANDERSON announces that he will begin a course of weekly lectures at University College, Gower Street, to ladies, on physiology, on Friday the 21st, at 4 P.M. The first lecture will be public.

MR. P. R. SCOTT LANG, M.A., B.Sc., F.R.S.E., who has for some years been assistant to the Professor of Natural Philosophy—Prof. Tait—in the University of Edinburgh, has been appointed by the Queen to the chair of mathematics in the University of St. Andrews.

MR. MARK FIRTH has signified his wish to found a chair of chemistry in connection with Firth College, Sheffield. He proposes to invest a sum sufficient to produce an annual income of 150*l*., and this, together with the fees of students, will amount, it is believed, to a sufficient sum. Mr. Firth proposes that the appointment shall be first filled by Dr. Carnelly, Owens College, Manchester.

THOSE of our readers interested in the higher education of girls may be glad to know that a Calendar of Queen's College, Harley Street, has been published.

THE *Golos* learns, according to the *Times* Berlin correspondent, that the Russian Government intends thoroughly changing the statutes of the University of Dorpat, in Livonia, that strong bulwark of German science and culture. Among the proposed alterations now under consideration in the Imperial Council, the chief one aims at restricting certain liberties hitherto enjoyed by German-speaking students and subjecting them to police surveillance similar to that now in force at all other Russian Universities.

SCIENTIFIC SERIALS

The American Journal of Science and Arts, October.—An examination of the chemical composition of amblygonite, by Mr. Penfield, leads him to give a new and more simple formula for the mineral. He shows that the hydroxyl group in amblygonite is isomorphous with fluorine.—From general geological sections in Iowa, Mr. McGee concludes that residuary clays and others of equal compactness were passed over by a thick ice-sheet with or without serious disturbance, and that the plane of contact between glacial drift and subjacent residuary clay is not always clearly defined.—Mr. Dale describes a peculiar fault at Rondout.—The first portion of a research, by Mr. Gibbs, on the vapour densities of peroxide of nitrogen, formic acid, acetic acid, and perchloride of phosphorus, is given, and the two remaining papers are from English publications (Crookes on radiant matter, and Draper on oxygen in the sun).

The American Naturalist, October.—John A. Ryder, an account of a new genus of minute pauropod myriapod (with figures).—Wm. Barbeck, on microscopical fungi attacking our cereals.—C. L. Herrick, fresh-water entomostraca (describes and figures *Diaptomus longicornis*, n.sp.).—S. K. Lum, notes on the thrushes of the Washington Territory.—John Ford, the leather-turtle.—S. L. Frey, Were they mound-builders?—Recent literature: Proceedings of scientific societies.

The American Quarterly Microscopical Journal, vol. i. No. 4. —Prof. S. A. Forbes, on some sensory structures of young dog-fishes.—Dr. C. L. Anderson, spores with a spore glossary.—Dr. J. J. Woodward, on the oblique illuminator, and on a new apertometer.—F. H. Wenham, on Prof. Smith's apertometer. —John Mayall, on measuring aperture.—R. Hitchcock, aperture, angular and numerical.—J. D. Hyatt, on the tongue of the honey-bee.—Thomas Taylor, on oleomargarine and butter.—W. C. Hubbard, Haeckel *v.* Virchow.—Prof. Stowell, the origin and death of the red blood-corpuscle.—B. Eyferth, on the simplest forms of life.—An announcement from the publishers states "that the existence of the *Quarterly* ceases with this number." The editor found that it would be impossible for him to give the journal the necessary supervision during the coming year, hence the necessity of this suspension.

Journal of the Franklin Institute, October.—Prof. Thurston here publishes an investigation of the strength of American timber, several varieties of which (white and yellow pine, locust, black walnut, white ash, white and live oak) were submitted to testing machines in the Stevens Institute. The results show that American timber has a constructive value equal, if not decidedly superior, to European timber. (The numbers were almost invariably higher than those of Barlow, Tredgold, or

Lastett.) Timber yields, under all forms of stress, to an extent about proportional to the load.—Mr. James Smith sketches a plan for water-supply of Philadelphia, viz., a gravity-supply by aqueduct from Perkiomen.—A modification of Tisley's compound pendulum, by Mr. Queen, of Philadelphia, whereby the motions and figures may be exhibited on a screen to large audiences, is described, and there is an account of the zinc veins and works of Lehigh Valley.

Bulletin of the United States Geological and Geographical Survey of the Territories, vol. v. No. 2, September.—J. A. Allen, on the Coatis (genus Nasua, Storr).—Dr. Coues, on the present status of *Passer domesticus* in America.—Dr. Peale, on the Laramie group of Western Wyoming and adjacent regions.—A. R. Grote, on Lithophane and some new Noctuidæ (describes many new species).—Dr. A. White, Palæontological Papers, No. II., on carboniferous fossils from Colorado, Arizona, Utah, and Wyoming, and on cretaceous corals from Colorado (describes several new species).—F. V. Hayden, the so-called Two-Ocean Pass.—E. D. Cope, on the extinct species of Rhinoceridæ of North America, and their allies.—Dr. Coues, second instalment of American ornithological bibliography.

Bulletin de l'Académie Royale des Sciences de Belgique, No. 8.—M. Plateau here defends, at some length, his theory of the superficial viscosity of liquids in opposition to the theory of Signor Marangoni, who, without denying a viscosity proper to the surface and different from that of the interior, thinks its influence (*e.g.*, in retarding the movement of a needle on the surface) very small in comparison with that of other causes, especially, in liquids which can be inflated in large bubbles, the *elasticity* of a layer of impurity (*imbrattamento*) arising from exposure in the air, while in liquids like water and most saline solutions, changes in tension, through alteration of the surface and changes in curvature of the menisci at the sides of the needle, &c., are operative.—M. Petermann writes on the presence of grains of *Lychnis githago* in alimentary flour, and indicates a method of detecting it.—There is also a paper on the quartziferous diorite of Champ-Saint-Veron (Lembecq), by MM. Poussin and Renard.

Journal de Physique, October.—On the inscription of meteorological phenomena, particularly electricity and pressure, by M. Mascart.—On the rectifying apparatus of M. Duboscq, by M. Bertin.—On a phenomenon similar to Peltier's phenomenon, by M. Bouty.—A regulator of temperature, by M. Benoit.

Cosmos, 5 Heft, August.—Prof. Dr. Schultze, history of the origin of the "Despising" of Nature.—Ernst Haeckel, on the common relationship between the ctenophora and the medusæ, with an account of a form connecting the two groups. This extraordinary form is beautifully figured.—Dr. Mehlis, the barrowfield near Hagenau and its probable epoch.—Henry Potonié, Alexander Braun's attitude towards the theory of descent.—Short notices and criticisms.

THE *Nyt Magazin for Naturvidenskaberne* (Christiania, vol. 24, pt. 4, and vol. 25, pt. 1).—From these parts we note the following papers:—On the geology of the Folge Fon peninsula, by T. Ch. Thomassen.—On the ornithology of Madagascar, by Leonhard Stejneger.—On microline, a new species of triclinic potash-feldspar; its optical, crystallographical, and chemical characters, by A. Des Cloizeaux.—On the insect fauna of Dovrefjeld and the Gudbrands valley, by W. M. Schoyen.—On the changes which some plants undergo in northern latitudes by Prof. F. C. Schübeler.—On the occurrence of iridium in northern minerals, by S. Wleugel.—On dislocation lines in the so-called Skrimfjeld, by O. E. Corneliussen.—Diary of a journey in the Trysil district, by L. Meinich.—Account of a botanical tour in Hardangervidden, by N. Wille.—On some contact rocks of the Christiania Silurian basin, by A. Penck.

THE *Verhandlungen der k.k. geologischen Reichsanstalt* No. 12, Vienna) contains the following papers:—On the miocene deposits at the south-western margin of the Galicio-Podolian Plateau, by J. Niedzwiedzki.—On the tertiary formation at the eastern slope of the Vogelsberg, by H. Bücking.—On the pliocene mammal-fauna of Hungary, by Th. Fuchs.—On the Flysch question, by the same.—On the geological objects exhibited at Teplitz and relating to the Teplitz basin, by R. Raffelt.—On the marginal mountains of the Vienna bay, by Franz Toula.—The number further contains the following eports of geological excursions undertaken by different members f the Reichsanstalt, viz.: by Dr. O. Lenz from Eastern Galicia, by Dr. Edmund von Mojsisovics from Bosnia, by E. Tietze from Eastern Bosnia, and by Dr. A. Bittner from the Herzegowina.

SOCIETIES AND ACADEMIES

LONDON

Linnean Society, November 6.—Prof. Allman, president, in the chair.—Mr. W. H. Twelvetrees (of Orenburg, Russia) was elected a Fellow of the Society.—The President, in opening the session, briefly alluded to the demise of Mr. W. Wilson Saunders and Mr. John Miers, whose scientific and official labours in connection with the Society have been well appreciated.—Mr. W. T. Thiselton Dyer exhibited and made remarks on some photographs of vegetation, including *Cinchona Ledgeriana*, in the Botanic Garden of Buitenzorg, Java.—Mr. D. Morris, recently returned from investigating the coffee-leaf disease of Ceylon and South India, read a paper on the structure and habit of *Hemileia vastatrix*. He supports the Rev. R. Abbay's statements as to the destructive character of the fungus and its evident gradual extension over the coffee-producing regions of the East; he even expresses fears of its ultimately being carried to the West Indies and Brazil;—2,000,000*l.*, the estimated annual deficiency in Ceylon alone, is no mean sum to be debited from the revenue and interests of the planters. Mr. Abbay has described the spores as attached to the inner surface of the orange-yellow sporanges (a notion opposed to received ideas respecting free cell formation); but Mr. Morris's observations are opposed to those of the former. The author explains the hitherto puzzling dark brown bodies beneath the sporanges as composed of closely interwoven threads of mycelium. During February, March, and April, both bark and leaves are everywhere covered exteriorly by mycelial filamentous threads which reproduce by germinating spores. In the wet weather these do not enter the stomata. It is in this stage that conidial growth supervenes according to Abbay (secondary spores of Thwaites), but the author has failed to substantiate this phase, though starved plants on glass slides raised conidia. It is during the filamentous stage before penetration that remedial agents—dusting with sulphur and lime, &c.—have a chance of being effective; but a serious disturbing element offers in the large area of abandoned crop still continuing to propagate the fungus.—Dr. F. Day read a paper on the instincts and emotions of fish. Biologists of late have been less attracted by the faculties of fish than of other animals, and even Cuvier's estimate of their total want of intelligence has been quite recently quoted as authentic. The author combats this notion, and, from his own experience and data afforded by other writers, claims evidence of emotions and affections. He shows they construct nests, transport their eggs, protect and defend their young, exhibit affection for each other, recognise human beings, can be tamed, manifest fear, anger, hatred, and revenge, utter sounds, hide from danger, betake themselves for protection to the bodies of other animals, and have other peculiar modes of defence, leave the water for food, and even different families combine for attack and defence. Their faculties, notwithstanding, are greatly subordinated and modified compared with those of higher races of the vertebrata.—The Rev. G. Henslow read a paper on the origin of the (so-called) scorpioid cyme. He pointed out some errors in deducing this from the dichotomous cyme: 1. Opposite pairs of bracts, being successively in planes *at right angles*, the resulting sympode would be a volute, and not a helix. 2. The position of the bracts (when present, as in *Borago*) are not opposite the flowers. 3. There are always *two* rows of flowers, not a single one. 4. The appearance of a flower in the fork between the two branches of the inflorescence (as in *Myosotis*) is not usual, and is due to the adhesion between the terminal and the highest axillary raceme. This has given rise to a false impression of dichotomy. 5. Authors have hitherto confounded the "true scorpioid raceme" (Henslow) with spicate degradations of sympodial inflorescence. He refers it to the indefinite system, and explains its origin by a new principle of phyllotaxis, which he first discovered in *Lagerstromia*, viz., in resolving opposite and decussate leaves into alternate, instead of their lying on a continuous spiral line, the line *oscillates* through three-fourths of a circle, and if a line be drawn from flower to bract, it will represent the so-called scorpioid cyme of Boragineæ.

Chemical Society, Nov. 6.—Mr. Warren De la Rue, F.R.S., President, in the chair.—The following papers were read:—On the transformation products of starch, by C. O'Sullivan. In this paper, which was originally presented to the Société Chi-

mique de Paris on June 18, the author criticises the results published by MM. Musculus and Gruber, pointing out some errors into which they had fallen. He reasserts the fundamental facts of his former paper, viz., that starch splits up under the influence of malt extract in four principal ways. The author also investigates the action of malt extract on the products of the above reactions. He inclines to the belief that the dextrins are not a series of polymers, but rather a series of bodies of the same molecular weight, the molecules being arranged differently as regards one another, the molecules being arranged in groups all dependent on one another.—Note on the formulæ of the carbohydrates, by Dr. Armstrong. The author discusses the various formulæ of glucose, and inclines to that which represents glucose as being an aldehyde and a penthydric alcohol; the cane sugars are probably related to the glucoses as ether is to alcohol. The author discusses the probable arrangement of the molecules in starch, and arrives at a conclusion differing from that of O'Sullivan.—On a new method of determining sulphur in coal, by Teikichi Nakamura of Tôkiô. The author mixes intimately one part of finely-powdered coal with three or four parts of sodium carbonate and ignites very gradually, so that no smoke or odorous gases escape; a white or reddish ash is left, which is treated with water, &c.—On the bromine derivatives of β naphthol, by A. J. Smith.—On the dissociation of ammonia iron alum, by J. S. Thomson. Dilute neutral solutions of ferric salts, when heated, deposit a basic salt; this dissociation can be prevented by the addition of dilute sulphuric acid. By using sulphuric acid of known strength, the author has studied the subject quantitatively. A solution of ammonia iron alum containing more than 1 grm. in 14·37 cc., does not dissociate; this dissociation begins in more dilute solutions, and increases regularly with successive additions of water; ammonia and potash salts increase the dissociation.—On α methyl oxysuccinic acid, the product of the action of anhydrous hydrocyanic acid upon aceto-acetic ether, by G. H. Morris.—Demarçay described an uncrystallisable acid obtained as above, whose baryta salt was unstable. The author has repeated the experiments, and obtained a well-crystallised acid melting at 108°. The barium salt is stable when boiled with water.—On the action of phosgene on ammonia, by H. J. H. Fenton. The author has examined the white amorphous substance obtained in the above reaction, and extracted guanidine and urea quite identical with ordinary urea.—On the rehydration of dehydrated metallic oxides, by C. F. Cross. The author has obtained various anhydrous basic metallic oxides by igniting the hydrates. These oxides, when exposed to a saturated atmosphere, absorb water up to a definite limit of a molecular character. The investigation includes oxides of aluminium, chromium, cobalt, iron, and copper.—On alizarin blue, by G. Auerbach. The author gives the method of preparing and purifying this substance; when pure it forms brown, shining needles, melting 268°–270°. He has also prepared various salts and bromo derivatives; the actions of zinc dust, chlorine, and acetic anhydride were studied. In constitution the author thinks the body must be closely related to the aldehydines of Ladenburg.

PARIS

Academy of Sciences, November 3.—M. Daubrée in the chair.—M. Mouchez presented the last published volume of *Annales de l'Observatoire de Paris*, giving observations made in 1876. He stated that the Ministry of Public Education had decided that a certain number of astronomical students should be admitted to the Observatory for two years' instruction and practice, after which those found fit should be appointed assistant astronomers in government observatories.—Nautical instructions on the coasts of Algeria, by M. Mouchez. The volume he presented describes first the meteorology, then the physical character of the coast.—Experiments with an inverted syphon having two horizontal branches, capable of raising water without a movable piece to considerable heights relatively to that of waves, or to exhaust at considerable depths relatively to the hollow of waves, when a retaining valve system is added, by M. De Caligny.—On some pathological states of the tympanum, causing nervous phenomena, which Flourens and De Goltz attribute exclusively to the semicircular canals, by M. Bonnafont. Displacement of the tympanic membrane away from or towards the internal wall of the tympanic cavity (*e.g.* in the latter case, by a concretion of wax or polypous excrescence), causes, through the chain of small bones, variations of pressure of the liquids in the vestibule and semicircular canals, with consequent giddiness, staggering, &c.—On the abnormal spectrum of light, by M. De Klercker. Two hollow glass prisms having the same angle (25°) and filled with alcohol, are placed on the stage of spectroscope with their refringent angles in opposite directions; the image of the slit is not deflected. To one prism are then added crystals of fuchsine; the original image then divides into two parts, one going to the right and widening into a distinct regular spectrum of the less refrangible rays; the other remains in the same place without widening, and takes a blue-violet colour. M. De Klercker attributes the effect to the different amount of retardation by molecules of different species in the solution.—On determination of the elements of a vibratory motion; measurement of amplitudes, by M. Mercadier. He uses a (so-called) vibrating micrometer.—Stomachic digestion and duodenal digestion; action of pancreatine, by M. Defresne. Hydrochloric acid in gastric juice is combined with an organic base which moderates its action and changes its properties. The acidity of mixed gastric juice, half an hour after ingestion, is no longer due to chlorhydrate of leucine, but to lactic, sarco-lactic, tartaric, malic, and other acids. The best reagent of this transformation is pancreatine. This difference in acidity of pure and mixed gastric juice becomes still more manifest in artificial digestion of nitrogenised food.—Result of researches into the origin of reinvasions of phylloxera, by M. Faucon. He contends for the superiority of submersion to insecticides, and indicates a method.—On uniform analytic functions in the neighbourhood of a singular essential point, by M. Picard.—On the ultra-violet absorption spectra of nitric and nitrous ethers, by MM. Soret and Rilliet. The known characters of the absorption spectra of metallic nitrates are not met with in nitric ethers. A solution of amylnitrous ether gives six absorption bands between H and R.—On a new stellar spectroscope, by M. Thollon. He uses two compound direct-vision prisms of special form (one in the collimator, the other in the telescope tube), whereby he seeks to reduce the loss of light as much as possible. The larger of the simple (or component) prisms has an angle of 100°, and contains a mixture of ether and sulphide of carbon; and two rectangular prisms of crown glass (one on either side) have faces parallel to each other and to the bisecting line of the angle of 100°.—On the tensions of vapour of saline solutions, by M. Pauchon. The value of coefficient a, in Kirchhoff's formula, varies continually with the concentration, in some cases increasing, in others diminishing.—On an electro-capillary thermometer, by M. Debrun. The principle is that mechanical action deforming a mercury meniscus like that in Lippmann's electrometer, produces a current.—On animal cellulose or tunicine, by M. Franchimont. The difference between animal and plant cellulose, if such exist, is not due to a difference of the groups $C_6H_{10}O_5$ forming it, but to a difference in the manner of their union.—Researches on the different modes of combination of phosphoric acid in the nervous substance, by M. Jolly. In the calf the brain is very rich in phosphorised elements; in the grown ox it is the spinal cord that contains most of them; and after alkaline phosphates, phosphate of iron is the most abundant.—On hairs and hairy glands in some kinds of Nympheaceæ, by M. Heckel.—On the growth of stems of dicotyledonous trees, and on the descending sap, by M. Guinier. He thinks it is perhaps time to renounce the ordinary theory of descending sap.

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